

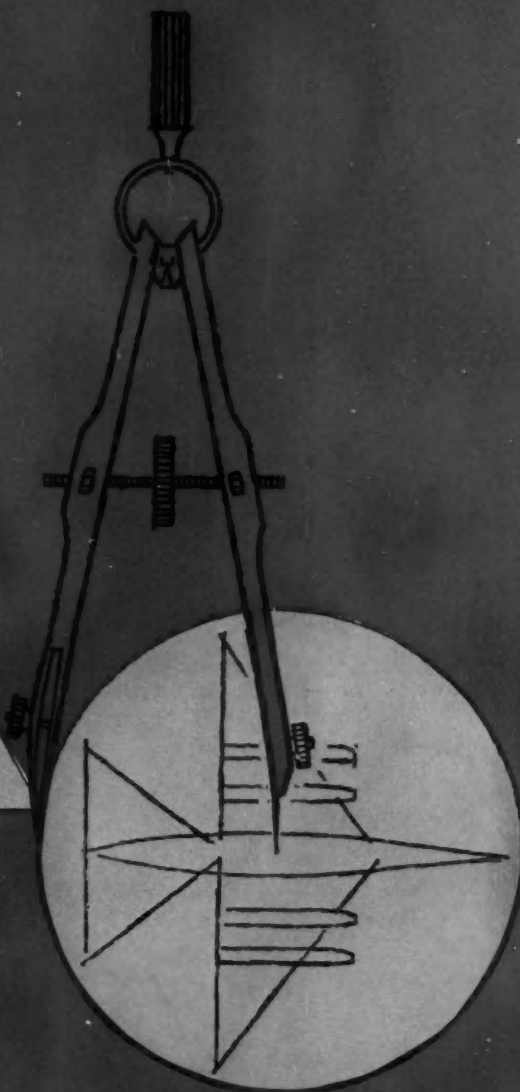
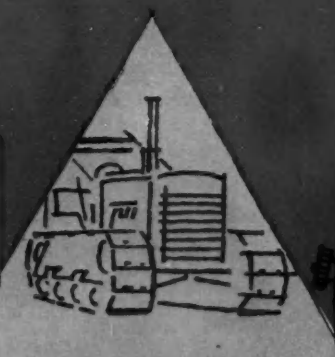
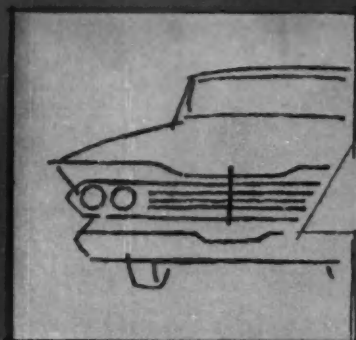
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JUNE 1961



JOURNAL

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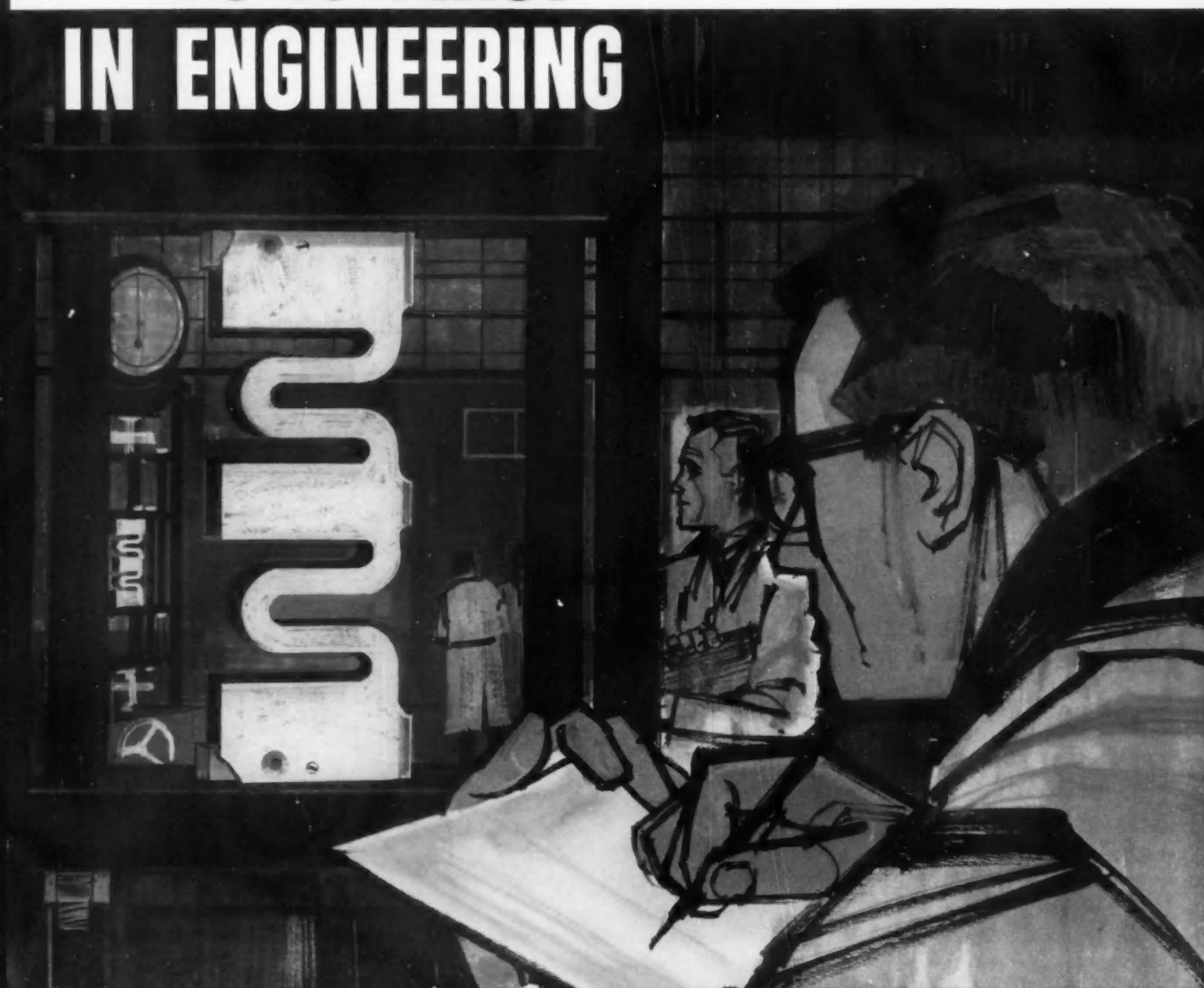
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Lincoln Continental driveshaft is smaller 35

The 1961 Lincoln Continental incorporates a constant velocity double Cardan universal joint, recirculating roller bearing spline, forged end yoke, and rubber element. These features are designed to save space, allowing a reduction in body dimensions, and provide smooth operation. (Paper No. 320D) — D. R. Veazy

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Providing better air for bottled up men 80

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A new, recently tested "composite adhesive" raises hopes that adhesives can be used to produce lightweight, high-strength, solid rocket motor cases. The "composite adhesive" differs from the conventional type, in that it has a varying shear modulus. (Paper No. 330C) — **Samuel J. Dastin and Philip Rosenberg**

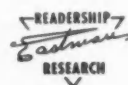
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SAE JOURNAL, June, 1961, Vol. 69, No. 6. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. \$1 per number; \$12 per year; foreign \$14 per year; to members 50¢ per number, \$5 per year. Entered as second class matter, Sept. 15, 1948, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of Feb. 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y. Second class postage paid at Lancaster, Pa. and additional office N. Y. C.

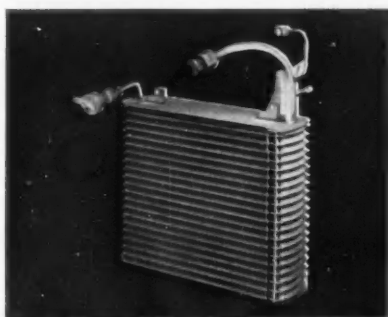
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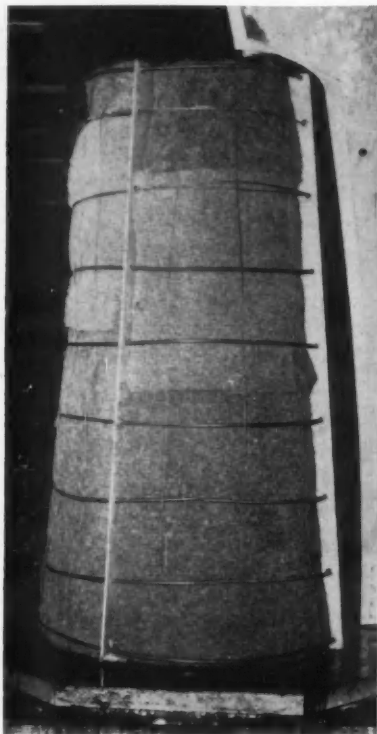


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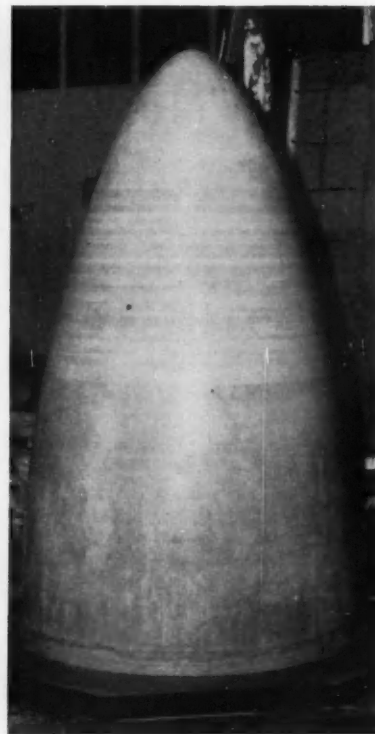
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FUELS & LUBRICANTS

Wear Problems Influence Motor Oil Development, W. S. HOOCK, M. P. KLEINHOLZ. Paper No. 300B. Wear tests required to predict overall anti-wear properties of lubricant are considered such as use of radioactive technique for measuring piston ring wear and engine tests to measure valve train wear; tests made to study effect of new oil additive, nickel dithiophosphate, in preventing wear of rocker arm shafts; research to study mechanism of its action; results obtained.

CLR Engine — Useful Tool for Evaluating Sludging Tendencies of Motor Oils, W. E. PARTRIDGE, W. F. RITCHESKE. Paper No. 300C. Single cylinder laboratory engine test evolved at Texaco, Inc., for evaluating "light-duty" deposit forming characteristics of motor oils reliably indicates oil performance in passenger cars; test is based on knowledge of mechanism of deposit formation in combination with studies of influence of engine operating variables.

Gasolines of the Future. THOMAS P. DEMUTH. Paper No. S290. Very brief summary of possibilities. Concludes that future improvements in the gasoline engine will depend largely on increasing compression ratios. Fuels used by these engines will have a high R.O.N., low sensitivity, and additives for surface ignition control.

Service for Added Profit. H. G. RUDOLPH, Jr. Paper No. S296. Discusses briefly various services available to contractors for maintenance of equipment from petroleum suppliers — at no charge to the customer. Covers chiefly those services pertaining to good housekeeping, recommendation, and application of lubricants to preventive maintenance.

GROUND VEHICLES

New Lark VI Overhead Valve Engine, T. A. SCHERGER, E. M. SABO,

H. R. JOHNSON, Jr. Paper No. 307F. Design objective and problems encountered during development program of OHV 6-cyl engine which has 3 in. bore and 4 in. stroke giving displacement of 170 cu. in.; it delivers 154 lb-ft of torque at 2400 rpm and 112 bhp at 4400 rpm; cylinder block and head, manifolds, valve train, camshaft, and oil pump; performance and economy; chart shows comparison between 1960 and 1961 6-cyl Larks made over four different test routes with three available transmissions.

Ford Econovan in Fleet Applications, J. L. HOOVEN. Paper No. 313A. Objectives of Econoline program and introduction of series of light weight commercial vehicles, van, bus and pickup truck; van was parent model which determined basic requirements; dimensions of van which has load space of 204.4 cu ft behind seats; Falcon 144 cu in. engine has modifications to adapt it to truck usage; transmission is modification of 3-speed Ford truck transmission; suspension, steering and

electrical system; major maintenance operations.

Basic Passenger Vehicle Construction or Unitized vs. Body-Frame, D. N. FREY, J. W. RICHARDS. Paper No. 317A. Present status of body/frame and unitized monocoque and integral frame structures; evaluation of relative merits of each; predominant factor that influences choice of construction is obsolescence of facilities and requirement for new equipment; magnitude of problem is shown by studying requirements for switching Ford car produced in plants equipped to build body/frame cars; present applications of unitized construction and predictions as to future usage.

Design and Development Flexibility with Separate Frame-Body Construction, M. A. BOWMAN. Paper No. 317B. Comparison of separate frame body and body frame integral con-

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struction showing each method on its own merits and in light of specific application, on basis of current designs and equivalent quality; testing facility of Dana Corp. for evaluation of frame durability, structural design and product reliability; unitized construction is successful in low horsepower short wheelbase cars while separate frame body construction has advantages in longer wheelbase cars.

Separate Frame and Frame-Integral — Why Use Both? J. B. BELTZ. Paper No. 317C. At Oldsmobile Div. of General Motors Co. both approaches were developed in same engineering department to provide organization with background of experience in each type of construction; comparison of concepts and design features illustrates advantages of each as used in each car; it is concluded that choice between separate frame and frame-in-

tegral is determined by objective of car being designed; comparison of date of F-85 body frame integral and full size car.

Separate Chassis Frame, W. G. PIERCE. Paper No. 317D. Comparison of separate frame and integral frame approach as to styling, isolation, stiffness, safety, versatility, and weight; it is concluded that on economic basis, quality differences, and versatility of separate frame, integral construction will return to its original interest, i.e. small car; integral frame cars above 100-in. wheelbase could have been built with equal weight and package room conditions, better isolation from road noise, vibration, and harshness, using latest separate frame technology.

Convenience in Motion — Power Operated Body Mechanisms, D. D. CAMP-BELL. Paper No. 318A. Basic units classified as power body mechanisms driven by electric, vacuum or hydraulic mechanisms are windshield wipers,

power seat adjusters, window regulators, power door and power deck lid locks, and power convertible top actuators; how each mechanism operates is explained on basis of overall concept of design.

Low Tunnels Mean High Angles, D. P. MARQUIS. Paper No. 320C. General Motor's approach in design of driveline for 1961 Tempest and Buick cars calling for low silhouette; adequate cushion, low tunnel and minimum of disturbances; drivelines demonstrate two ways to bend line of action; connection of torque carrying shaft to element moving up and down with suspension is accomplished by universal joint; when high angles of operation are required, double Cardan joints are indicated.

Molded Fiberglass Topliner, N. P. KIMBERLY. Paper No. 321C. Historical background on headlining installations and development of topline; method of manufacture used at Johns-Manville plant, Defiance, Ohio; layer of "uncured" fiberglass insulation (80% glass, sprayed with 20% phenolic resin by weight), polyethylene film and fiberglass decorative trim fabric, frame loaded, are placed between heated molds; advantages for manufacturer and user.

Tire Uniformity, M. G. ANDERSON. Paper No. 322B. Forms and types of discontinuities in tires which relate to thump, roughness, and shake, carcass deformation which takes place when tire is deflected against ground; types of irregularity which excite vibration are variations in physical dimensions of inflated tire; modified machine used to measure irregularities; three linear potentiometers measure radial runout at tread center and at each shoulder; lateral wobble is measured at center of each sidewall; curves obtained relating to radial, lateral and tangential force variation, radial and lateral runout.

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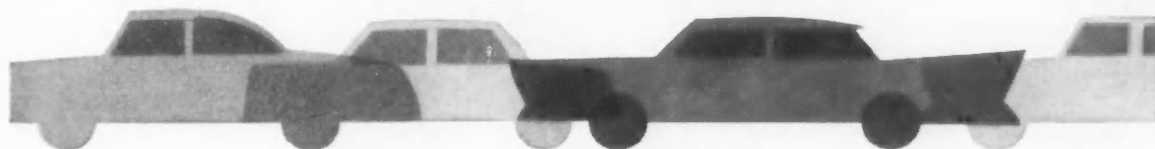
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THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street  New York 5, N. Y.

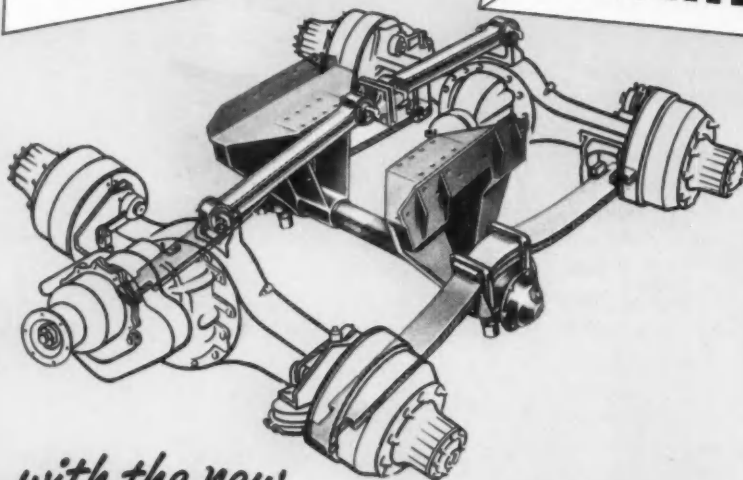
INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

COMBINE

PAYLOADABILITY

with **RIDEABILITY**



and get

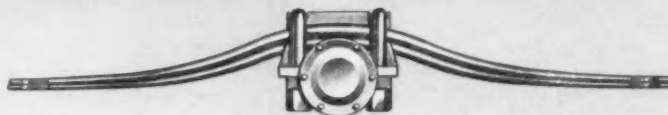
- UP TO 434 LBS.
MORE PAYLOAD
- A SMOOTHER RIDE
LOADED OR EMPTY
- LESS WEAR AND
TEAR ON TRUCK
AND CARGO

with the new

ROCKWELL-STANDARD TANDEM SUSPENSION

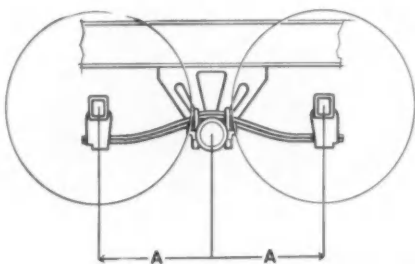
COMPLETELY NEW
IN DESIGN...

EXCLUSIVE "TAPER-LEAF" SPRINGS
MEAN LESS WEIGHT—
MORE PAYLOAD



It isn't the amount of spring steel but the way that it is used that gives strength to springs. With only *two* long tapered leaves in each spring Rockwell-Standard can achieve the same strength and load carrying capacity that standard suspensions can carry with multi-leaves...and at less than half the weight.

Optional aluminum frame support brackets and torque rods cut suspension weights by almost 25%.



Another Product of...

BALANCED "CRADLE-RIDE" FOR SMOOTHER GOING—LOADED OR EMPTY

Balanced design with long resilient springs assures an easy buoyant ride and reduces vehicle hopping, pitching and swaying. Because of greatly reduced inter-leaf friction even slight road imperfections are absorbed. This shock absorbing action keeps vehicles tight, minimizes maintenance, reduces cargo damage and makes handling easier on or off the road.

ROCKWELL-STANDARD
CORPORATION



Transmission and Axle Division, Detroit 32, Michigan

What synthetic sealing materials should I use—and when



Environmental conditions generally dictate the type of synthetic rubber for a specific oil sealing application.

Where temperature, shaft speed, runout, eccentricity, and lubricant type are "normal", standard Buna N synthetic rubber compounds are satisfactory. If, however, the application is "dry running", a compound must be selected that will operate satisfactorily with a very small amount of lubricant. If the application involves excessive abrasion, highly "loaded" compound stocks should be provided. At temperatures over 250° F polyacrylics or silicone compounds are indicated; if high temperature is accompanied by a solvent base or additive lubricant, polyacrylics are definitely preferred.

Thus many variables govern successful oil sealing. The chart below gives more data; for complete information from the world's foremost oil seal laboratories, call your National Seal engineer. He's in the Yellow Pages, under Oil Seals or O-Rings.

SYNTHETIC RUBBER COMPOUNDS					RECOMMENDED APPLICATIONS				
Comp. No.	Base Polymer	Min/Max Operating Temperature	Life Index	Price Index	Automatic Transmissions	Pinions	Axle Seals	Engine Seals	Misc. Applications
B-63	Buna N	—40°F/225°F	100	100				Excellent for small gas engines.	Excellent for small non-spring loaded seals.
B-86	Buna N	—30°F/225°F	100	100		Satisfactory for medium temperature applications.	Truck and automotive rear axles. General use.	Satisfactory as general purpose material where temperature permits.	General purpose Buna N applications.
B-94	Buna N	—60°F/250°F	100	100					Excellent against aromatics and some military aircraft oils, fuels.
B-95	Buna N	—30°F/225°F	100	100					Good dry running compounds for applications requiring high durometer stock.
C-6	Buna N	—30°F/225°F	100	100			Excellent for semi-rough axles. Has good wear qualities.		Good for pressure seals due to high durometer and clean trimming.
L-28	Acrylon BA-12	—30°F/300°F	400	125	Good for temperature range indicated.	Satisfactory in single lip construction.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general applications. Can be used with EP or GL-4 oils.
L-34	Hycar PA-21	0°F/300°F	400	115	Good for temperature range indicated.	Dual lip limited contact for high temperatures.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general single or dual lips. Ok with EP or GL-4 oils.
S-48	Silicone*	—80°F/400°F	1500	150	Excellent high and low temperature life.	Silicone Compounds Not Recommended With EP Lubricants at high temperatures.		Excellent for general engine use. Suggested for premium gasoline and Diesel engines.	Excellent wide range material. Avoid use in EP and GL-4 oils.
S-49	Silicone*	—80°F/300°F	600	130	Good at high and low temperatures.			Very good for general engine use; premium gasoline and Diesel engines.	Very good wide range material. Avoid use in EP and GL-4 oils.

*Silicones require special stabilization for satisfactory use in aromatic oils at high temperatures.



NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.

GENERAL OFFICES: Redwood City, California

PLANTS: Van Wert, Ohio; Redwood City and Downey, California

Dependable Natural Gas Power...



A milestone in public education was reached this year as a Clearwater, Florida school experiment set out to compare air-conditioning operating costs and student achievements. Although building contracts for the new schools were comparable, the air-conditioned school, above, actually cost less to build because design was more compact, with reduced roof and corridor construction. At left, 7th grade science students stay cool and fresh, sustain interest throughout the day in climate controlled classroom.

Florida project relies on International engines to keep operating expense at reasonable level...

A new era for municipal air-conditioning may be the result of a school project getting underway in Clearwater, Florida. It is believed that climate control in the classroom will improve student comfort, promote alertness, reduce illness and absenteeism, and generally upgrade the education of our children. Although industry has universally accepted the merits of air-conditioning, school and municipal officials question its value when confronted with the cost and operating expense of reliable cooling equipment. The Clearwater project will answer this question.

The project began with construction of two junior high schools—the Oak Grove School in Clearwater and the Pinellas Park School in St. Petersburg—each one comparable in cost and capacity. The Clearwater school is air-conditioned, the other is not. Comparison of operating expenses and educational achievements during the 1961-62 season will determine if climate control is worth the extra appropriation.

To keep operating costs at a minimum, school officials chose a natural-gas-powered system with outstanding characteristics of economy and efficiency—two Ready-Power 60-ton units driven by two International U-450 engines. The IH-powered system operates from 9:30 am to 4:30 pm, bringing class-

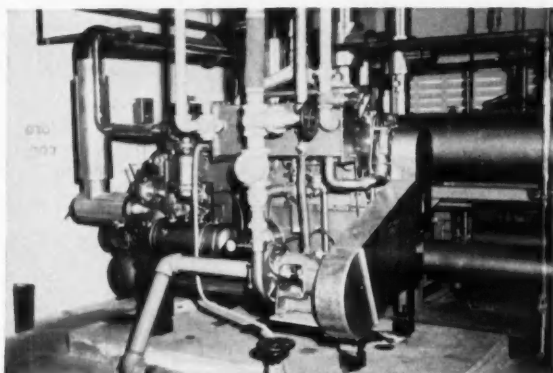
room temperature to the desired level within 30 minutes. Water enters the line at approximately 90° F and leaves the system at 48° F. Return water is approximately 51° F. The separately-housed system keeps 24 classrooms and the gymnasium at about 72° F regardless of outside temperatures.

When you turn to International for air-conditioning power, you join an ever-increasing number of engineers and contractors who specify IH engines for dependable, low-cost installations. The wide range of sizes in the IH line—35 diesel and carbureted models from 16.8 to 385 max. hp—gives you matched power for all heavy-duty jobs. For complete information contact International Harvester Co., Engine Sales Dept., Melrose Park, Ill. For specific information on air-conditioning, fill out the coupon on the page opposite.

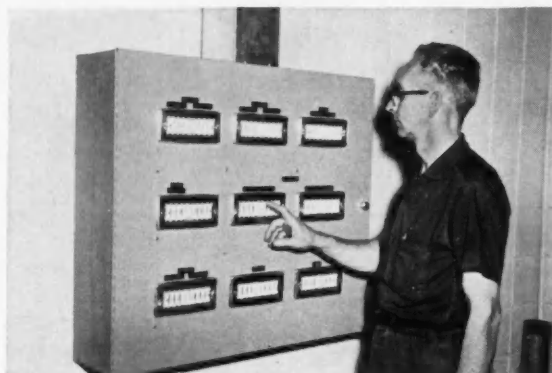
INTERNATIONAL®
IH ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

New Key to Low-Cost Municipal Air Conditioning



Officials who specified cooling equipment for the Clearwater project naturally turned to the most economical units they could find. Two natural-gas-powered International U-450 engines drive two Ready-Power water chillers in this low-cost system. Installations throughout the country indicate that International engines provide the most economical air-conditioning power available.



Operating Engineer J. E. Pratt controls temperature of each room and gymnasium from this master panel. Each classroom accommodates 35 students. The school began with 665 students, now has a total enrollment of 1,200. Provisions have been made for additional air-conditioning equipment as extra rooms are added to the present facility.

For descriptive literature spelling out the advantages of International natural gas powered air-conditioning, send for colorful, illustrated booklet. Fill out the coupon and mail it today!

Mr. R. R. McKiel
Engine Sales Dept.
International Harvester Co.
Melrose Park, Ill.

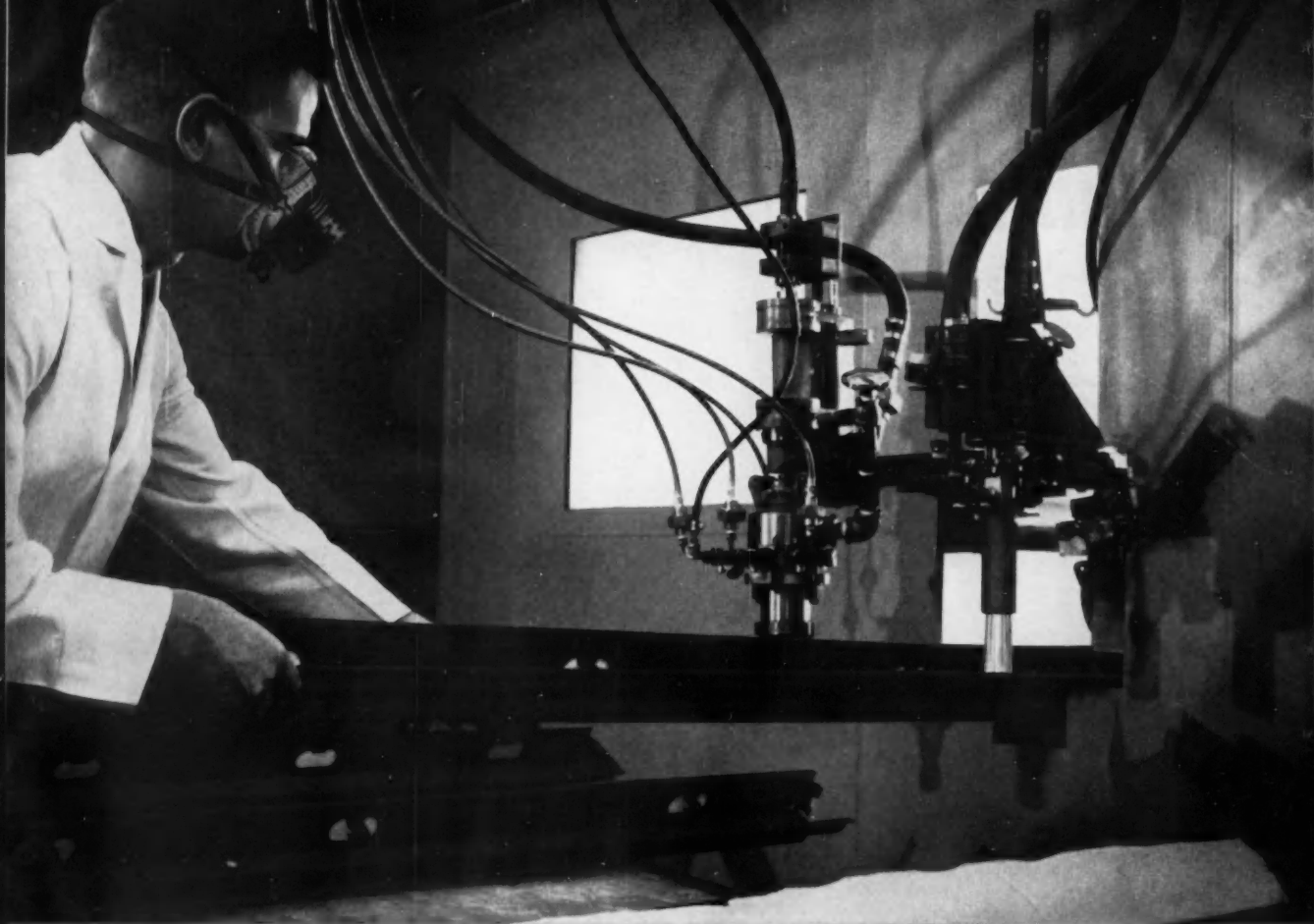
Please send me the booklet on natural gas air-conditioning.

NAME _____

FIRM _____

ADDRESS _____

CITY _____ STATE _____



FOAMED-IN-PLACE, RIGID URETHANE

... one product answers five automotive needs

Voracel® foamed-in-place rigid urethane can show definite economic advantages over cut-and-paste batt applications. These advantages are: *insulation, structural support, sound deadening, "pocket sealing," and surface protection.* Application of Voracel can be accomplished by either a spray or pour operation.

Voracel is the Dow trademark for the rigid urethane foam resulting from the interaction of Voranol® urethane polyethers and Voranate® isocyanate adducts.

Although new on the automotive scene, Voracel shows excellent results in strengthening sheet metal, especially when it is foamed in place between two sheets. Exceptional ease of application, good adherence to metal, and high resistance to alkali, gasoline, and other common automotive mate-

rials indicate its use as lining for hoods and other sheet-metal areas. Voracel can be used to inhibit corrosion in enclosed areas such as rocker panels. For information, call or write to the Dow sales office nearest you.

ENGINE COOLING Ebullient cooling for passenger cars is under intensive research at Dow's Automotive Chemicals Laboratory and seems headed for broad use because of its obvious advantages. The increased efficiency of a vapor system is expected to allow smaller radiators and more freedom of placement—for example, under the floor or in the trunk. This thought is intriguing to designers!

DEGREASING Chlorothene® NU specially inhibited 1,1,1-trichloroethane is continuing to make news in on-the-line cold degreasing because of its safety and efficiency. Chlorothene NU

combines the property of low toxicity and no fire or flash point, as measured by standard methods. And corrosion-prone white metals show a high tolerance for Chlorothene NU.

DOW AUTOMOTIVE CHEMICALS LABORATORY

Created expressly to serve the needs of the automotive industry, Dow's Automotive Chemicals Laboratory is active in technical service and development. This laboratory is continually researching and developing coolants, hydraulic fluids, cutting and grinding fluids, functional fluids, fuel and lubricant additives, and synthetic lubricants. To see how this laboratory can be of assistance to you, contact your nearest Dow sales office or write Chemicals Merchandising in Midland.

THE DOW CHEMICAL COMPANY

DOW

Midland, Michigan

TOP RING TO OIL RING... THE WORKS FOR A WORKHORSE



Koppers supplies packaged piston ring set for Caterpillar's husky D8 crawler Tractor

Extra stamina is demanded of every part of Caterpillar's massive D8 Tractor because it's built to push or pull the heaviest loads over the roughest terrain. This "something extra" is evident in the D8's powerful 235 HP turbocharged diesel engine—complete with packaged piston ring sets by Koppers.

Says Caterpillar: "The D8 Tractor is designed to excel; built to last. Take its 235 HP engine, for example. A 20% torque rise provides excellent lugging characteristics to meet critical loads. It's designed specifically for hard work, with dependability, economy and low maintenance. The Koppers rings we are using meet our requirements of quality and dependability."

Write today for complete information to: KOPPERS COMPANY, INC., Piston and Sealing Ring Dept., 6906 Hamburg St., Baltimore 3, Md.

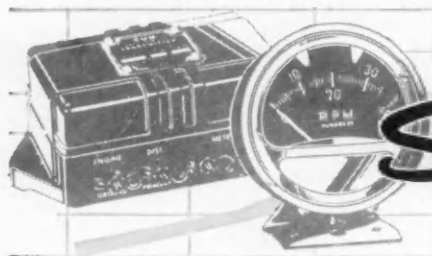
That's a completely Koppers ring equipped piston you're looking at. From the precision lapped, chromium plated, high strength alloyed iron compression ring in its top groove to the chromium plated, conformable, spring loaded, ventilated oil ring in the bottom groove. This set-up guarantees fast break-in and longer life resulting in peak efficiency for Caterpillar's 235 HP diesel engine.



PISTON & SEALING RINGS

Engineered Products Sold with Service





Sun TACH-O-GRAM

One in a series of technical discussions on Tachometers.

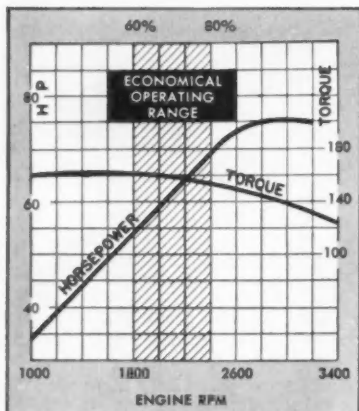
Vehicle Operators Agree Sun Electric Tachometers Help Reduce Engine Wear

Fleet owners, through the use of carefully kept comparison records, have proved that Sun Electric Tachometers make a big difference in reducing engine wear... and even gas and oil bills.

These records show that Sun Tachometer equipped vehicles actually had longer engine life, along with a pronounced reduction in overall maintenance costs. Here's why.

Economy Operating Range

Every engine has an economic operating range—60% to 80% of the speed at which it delivers its rated horsepower. Frequent engine operation above or below the economical operating range results in high fuel consumption, excessive strain, and premature wear on vital engine parts.



A Sun Electric Tachometer helps prevent this. It tells the driver when to shift gears to stay in the economy range. All he need do is keep the Tachometer Indicating Hand between the two white arrows. These arrows which are pre-set to mark the high and low points of the proper RPM range.

Critical RPM Zone Kept in View

Because this range is always in view, drivers avoid such hazards as "lugging" and "overspeeding." They're able to get maximum fuel miles per gallon. And on fleet maintenance record sheets, this

care shows up as maximum trouble-free engine performance—reduced engine wear—lower service costs.

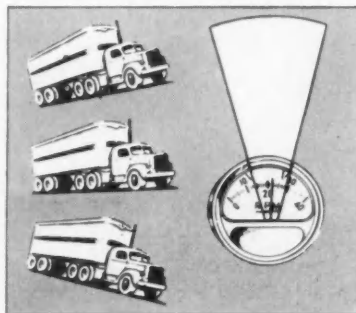


Diagram shows how on "up hill long pulls," "level cruising," or "down grade driving," Sun Tachometers show driver when to shift to keep engine in correct RPM range.

Electric Type Preferred

Based on field test reports, operators have found that the Sun Electric Tachometer gives smoother, steadier, more accurate readings—and is less subject to pointer waver. The electric type is not affected as much by bumps, holes or washboard roads.

Bump Proof Because of "Ruggedized Accuracy"

This preferred "Bump Proof" feature of Sun Electric Tachometers, is made possible through the use of a rugged D'Arsonval Movement, with Jewels mounted in silicone rubber.

This greatly reduces shock or vibrations, and is not found on any other type or make Tachometer.

This is a Sun manufacturing exclusive, and is called "Ruggedized Accuracy."

It affords longer Tachometer life and greater accuracy. Beryllium hair-springs minimize spring fatigue.

Adding to this tough, "Ruggedized" feature, is the use of Alnico magnets, for permanent strength—and double bridge construction.



Wide Applications

These features add up to proven big benefits for fleet operators—and also are the reasons why Sun Tachometers are in demand for Automotive, Marine and Stationary engines; both Gasoline and Diesel types.

Samples Available

Why not look deeper into the "inside story" of Sun Electric Tachometers. By doing so you may find that for your application the electric Sun Tach is the best answer.

Samples are available immediately for engineering tests, along with reference catalog bulletins and print specifications. Just fill in the coupon below for immediate action. Thank you.

AVAILABLE FOR ORIGINAL EQUIPMENT OR REPLACEMENT

Sun
ruggedized
ACCURACY

ELECTRIC TACHOMETERS
Makers of Electric Tachometers for Automotive, Marine and Stationary Engines; both Gasoline and Diesel.

NEW

Sun Electric Corporation
Tachometer Division
6361 N. Avondale Avenue
Chicago 31, Illinois

New "Facts Folder" tells all about SUN Electric Tachometers.

☐ Send literature and installation instructions.

☐ Have your representative call with sample Tachometer. Specify: (Gas _____ or Diesel _____ application)

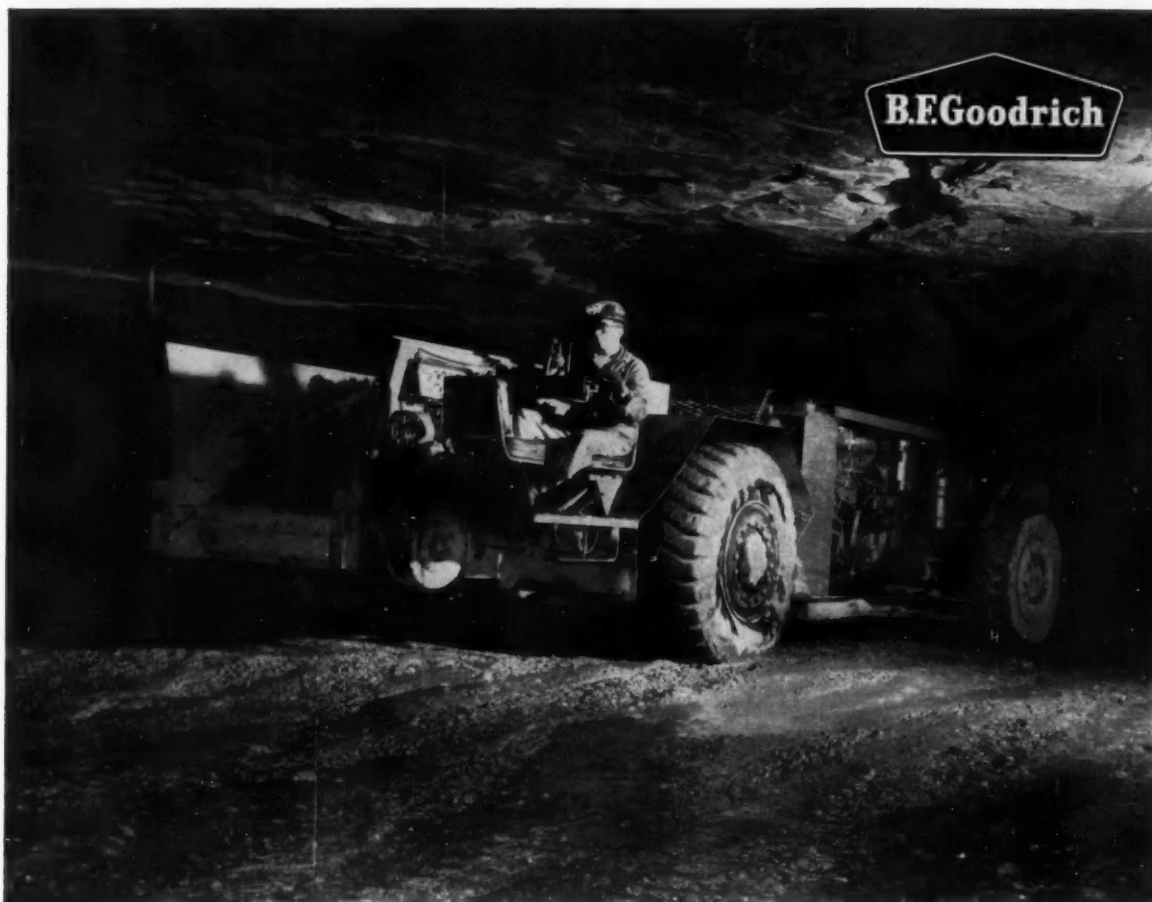
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Title _____

Firm _____

City _____ Zone _____ State _____

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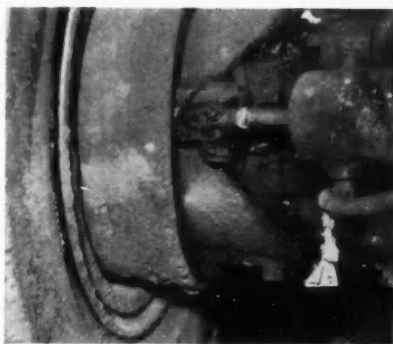
Hi-Torque brakes make underground hauling safer; hold 44 tons on 20% grades

This shuttle car is one of several KW-Dart vehicles in use at the White Pine Copper Company mine at White Pine, Michigan. The cars are equipped with B.F. Goodrich Hi-Torque brakes, designed for heavyweight off-the-road vehicles.

Each car weighs 44 tons fully loaded with copper ore. White Pine reports the ability of Hi-Torque brakes to handle such heavy loads safely is an outstanding advantage. With full loads, the vehicles hold on steep grades encountered in the mine, ranging up to 20 percent.

The cars are being used on a round-the-clock basis, 7 days a week, with brakes applied most of the time the vehicles are moving. Yet in several months of operation no maintenance or replacements have been required.

You can use these brakes in *your* heavy-duty vehicles with a minimum of design change. Call or write *B.F. Goodrich Aviation Products*, a division of *The B.F. Goodrich Company*, Dept. SJ-6, Troy, Ohio.



Closeup of Hi-Torque brakes on shuttle car wheel. The cars are used over hilly, rocky and muddy terrain.

B.F. Goodrich Hi-Torque brakes

NOW....

**the most paintable-durable-weldable
zinc-coated steel yet produced**

....NEW ARMCO

Spangle-free Armco ZINCGRIP® A, PAINTGRIP® is a zinc-coated steel specially prepared to take an ultra-smooth, lasting paint finish.

You can paint its spangle-free surface right after fabrication. Three years of outdoor tests show paint adherence and paint life on ZINCGRIP A, PAINTGRIP superior to phosphate-treated cold-rolled steel and to all other zinc-coated steels prepared for painting. And its hot-dip zinc coating keeps rust away when paint is damaged—protects from corrosion where there's no paint at all.

WELD IT

Tests with production equipment show *two times as many spot welds* can be made on ZINCGRIP A, PAINTGRIP as on ordinary galvanized steel before electrode tips need redressing. It's every bit as workable as Armco ZINCGRIP—the original hot-dip, zinc-coated steel, proved in severely fabricated products for more than a quarter-century.

New Armco ZINCGRIP A, PAINTGRIP is available now in gages from 16 to 24 and with 1.25 ounces per sq. ft. class coating or light commercial coating in cut lengths and coils up to 48 inches wide, depending on gage. Mail coupon for details.



Armco Division

ARMCO DIVISION

Armco Steel Corporation
1881 Curtis Street, Middletown, Ohio

PLEASE SEND more data on new ZINCGRIP A, PAINTGRIP

NAME _____ TITLE _____

FIRM _____

STREET _____

CITY _____ ZONE _____ STATE _____



New steels are
born at
Armco

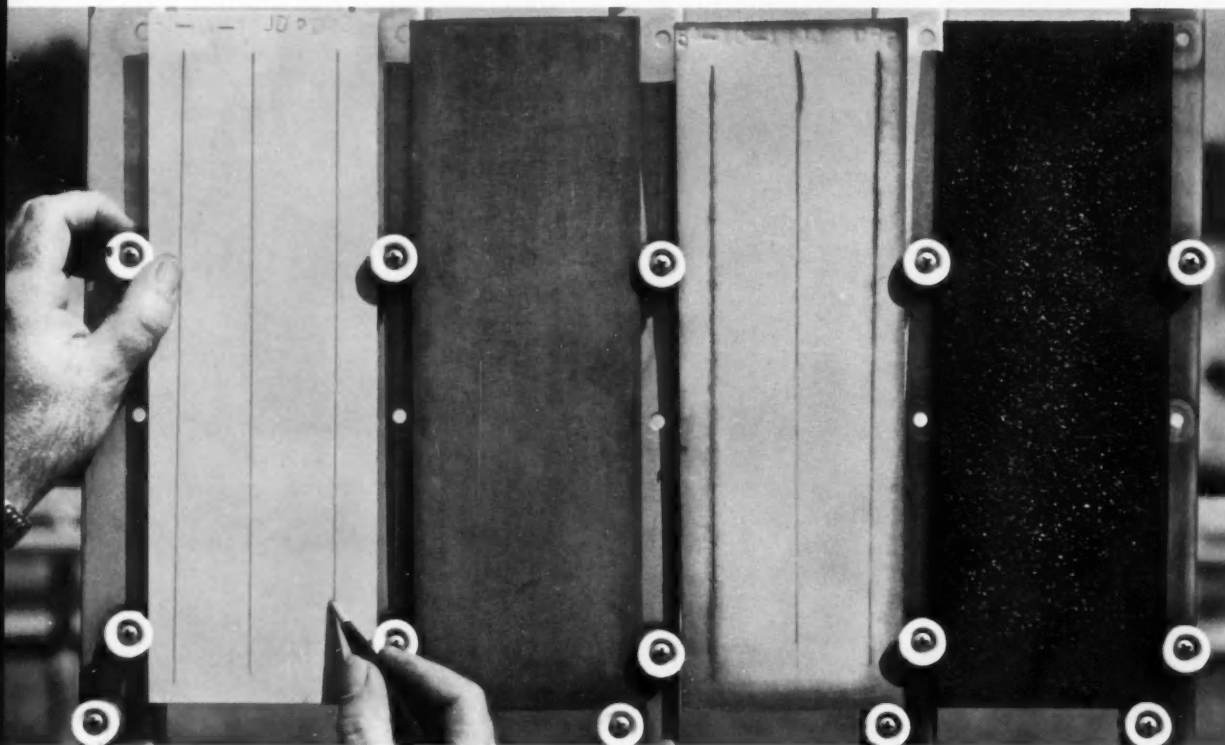
ZINGGRIP A, PAINTGRIP

1

2

3

4



◀ This half-painted bus body fabricated from Armco ZINGGRIP A, PAINTGRIP has been exposed for 2½ years. Paint finish is still smooth and attractive, the unpainted surface rust-free.

▲ After 3 years' exposure outdoors, paint holds tightly to sample (Number 1)—Armco ZINGGRIP A, PAINTGRIP—even in areas scratched at the start of the test. Unpainted ZINGGRIP A, PAINTGRIP (sample 2) also shows no rust. In contrast, the painted and unpainted phosphate-treated cold-rolled steel test panels (3 and 4) are in poor condition. Paint has been undercut. Rust is entrenched.



Use this label
to indicate durable
zinc-coated steels
in your products

AiResearch pressure suit cooling unit

*provides maximum pilot
comfort on the ground*



This portable, lightweight package keeps the pilot cool and comfortable on the ground in his flight pressure suit from one to two hours. Utilizing cryogenic liquid oxygen as the coolant, it requires no electric power or other connecting supplies which might hinder the pilot's mobility.

Easily carried by hand or slung from the shoulder, the AiResearch unit can cool a pilot wearing either full or partial pressure suit during travel to and from his aircraft, preflight checkout and while seated in the cockpit. Pure oxygen for prebreathing can also be provided as a simultaneous function.

This extremely simple and reliable cooling unit has no moving parts. In operation, ambient air vaporizes a supply of liquid oxygen to pressurize the system. Cooling air, made up of stored oxygen and ambient air, is then circulated through the suit.

AiResearch is also in production on self-contained life support systems inside fully enclosed protective suits. These suits allow the wearer to work safely in hostile environments such as toxic missile fuel handling and fire fighting. Research for modification of these systems is now being conducted for space use.

• Please direct inquiries to Los Angeles Division



AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

New P/S Klozure Oil Seal*



**Lasts
four times
longer**

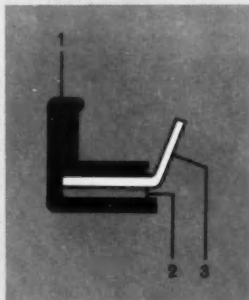
...Yet Costs No More! It's the seal of tomorrow for use today. Garlock P/S (Positive/Seal) KLOZURE Oil Seals with filled-Teflon** sealing elements offer the economical, built-in "permanence" demanded of modern design. They resist temperatures more extreme than ever encountered in normal operation; are chemically inert and unaffected by corrosion. They do not wear, nor score the shaft on which they are used; will seal at speeds to 3000 f.p.m. New Garlock P/S KLOZURE Oil Seals have been successfully tested on the GM Sealrater.

There's a lot more to the story of this fine new seal. Below are construction details; on the next page, you'll find application information. Send in the postcard and we'll send you an actual sample seal for examination. Garlock Inc., Palmyra, N.Y.

GARLOCK

Garlock P/S KLOZURE construction assures positive sealing:

1. STEEL SHELL OR CASE serves to enclose and position all component parts.
2. SPECIAL GASKET fitted tightly into position holds sealing element in place, provides extra leakage protection.
3. FILLED-TEFLON SEALING ELEMENT rides firmly against shaft, keeps oil in, dirt out.



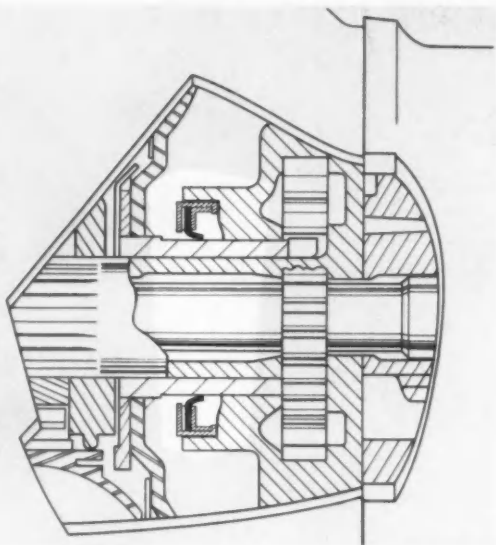
*Registered Trademark **Du Pont Trademark

FIRST CLASS
PERMIT NO. 2
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No postage stamp necessary if mailed in the United States

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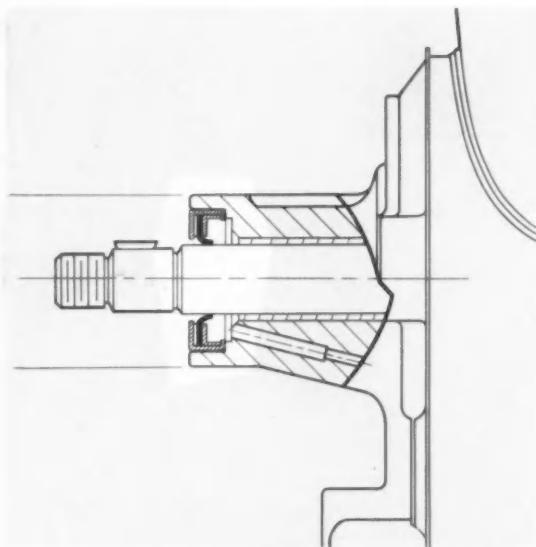
NEW P/S KLOZURE OIL SEALS



Cutaway shows general purpose seal in position. P/S KLOZURE Oil Seals outperform all others in standard 300-hour acceptance test.

FOR GENERAL PURPOSE APPLICATIONS . . .

. . . Garlock P/S KLOZURE Oil Seals outperform all others in a standard 300-hour acceptance test. Seals with synthetic rubber elements fail periodically, resulting in leakage. For example, nitrile rubber cracks and hardens; polyacrylate rubber loses its flexibility; silicone rubber swells and becomes soft. Garlock P/S KLOZURE Oil Seals emerge undamaged in tests run at 3600 r.p.m. speed on a $1\frac{1}{8}$ " shaft. Shaft-to-housing eccentricity is .010" t.i.r.; seal-to-shaft eccentricity is .010" t.i.r. P/S KLOZURE Oil Seals successfully resist Type "A" transmission oil at 300°F without harm or leakage.



Cutaway shows pump shaft seal in position. P/S KLOZURE Oil Seals outperform all others on standard 100-hour acceptance test.

FOR PUMP SHAFT SEALING UNDER PRESSURE . . .

. . . Garlock P/S KLOZURE Oil Seals are the ideal answer to the combined problem of speed, pressure, and temperature. Undergoing a standard 100-hour acceptance test, P/S KLOZURE Oil Seals outlast the synthetic nitrile, polyacrylate, and silicone rubbers that are in popular use today. Test conditions in this instance are an $\frac{11}{16}$ " shaft rotating at 6000 r.p.m. with an eccentricity of .003" t.i.r. shaft-to-housing. Here again, Garlock P/S KLOZURE Oil Seals are unharmed against Type "A" transmission oil at a maximum of 275°F., pressure of 50 p.s.i. Of special interest to pump manufacturers is the universal suitability of this seal against all types of fluids, including non-flammable. No need now to match various sealing elements to various fluids—P/S KLOZURE Oil Seals handle them all!

SEE US AT GARLOCK BOOTH 618
AT THE DESIGN ENGINEERING SHOW

GARLOCK INC.

Palmyra, N.Y. Twenty-six sales offices and warehouses throughout the U.S. and Canada.

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

I would like more data concerning the new Garlock P/S KLOZURE Oil Seal that lasts four times longer than ordinary seals . . . yet costs no more! Please:

☐ Send sample seal

☐ Have sales engineer call

NAME _____

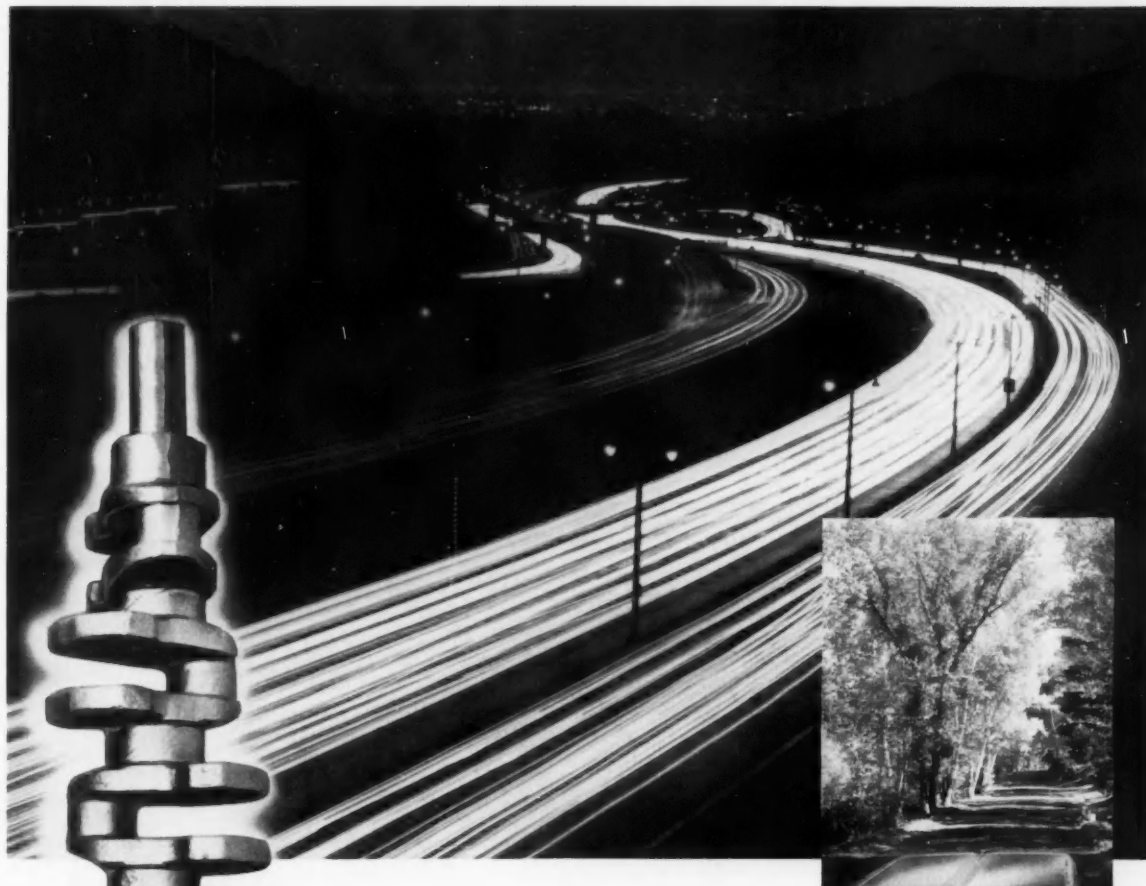
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SEND THIS POSTCARD FOR
FREE SAMPLE SEAL



on teeming freeway . . . or scenic byway

Forgings insure trouble-free miles

It's always the forward-looking design decision . . . and production economy as well . . . to specify forgings for highly stressed parts. No other process duplicates the inherent strength and toughness or develops desired physical properties with the precision and uniformity of a forging. No other process provides this insurance of trouble-free miles. But to get these benefits in full measure the forging source is of equal importance to the process. Wyman-Gordon's long association with automotive applications can prove invaluable in translating your designs into forged parts of highest reliability.

FORGED



EST. 1883

WYMAN - GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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WORCESTER MASSACHUSETTS

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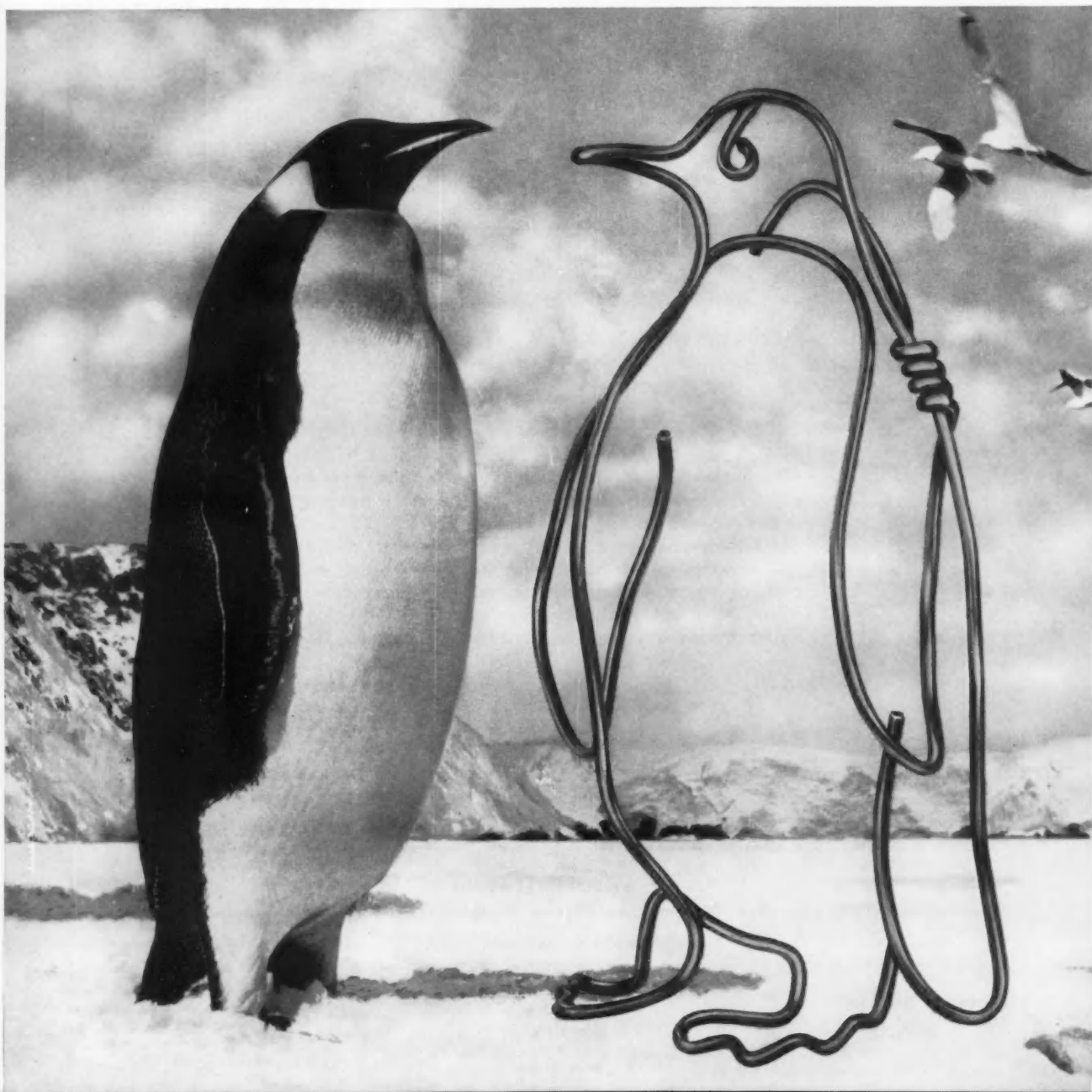
GRAFTON MASSACHUSETTS

LOS ANGELES CALIFORNIA

PALO ALTO CALIFORNIA

FORT WORTH TEXAS

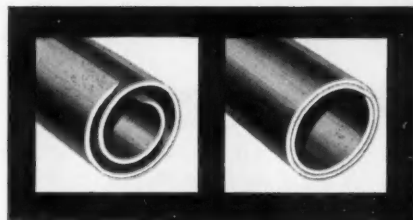
Bundy can mass-fabricate practically anything



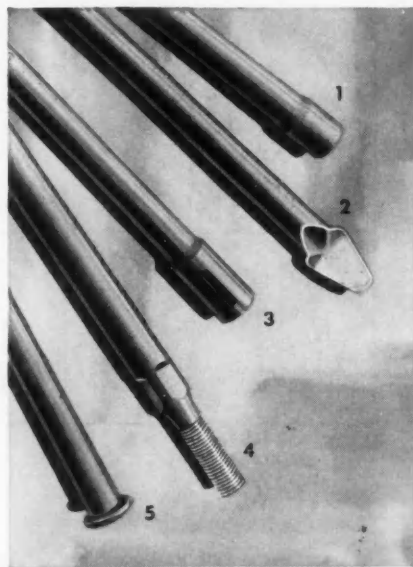
Need tubing? Maybe just a few simple bends . . . or millions of complex fabricated tubing parts. But, whatever your tubing requirements, come to Bundy. The important reason for Bundy's precision fabrication is Bundyweld® steel tubing. Standard wall thickness and O.D. of Bundyweld are held to $\pm .002"$ to $-.003"$. Bundyweld meets ASTM 254; Govt. Spec. MIL-T-3520, Type III. Precision comes first, but Bundy plants are also geared to give you the cost advantages of mass-fabrication. Be sure you get the most for your tubing dollar by talking to Bundy first. Call, write or wire: Bundy Tubing Company, Detroit 14, Michigan.

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World's largest producer of small-diameter tubing. Affiliated plants in Australia, Brazil, England, France, Germany, Italy, Japan.



Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes available up to $\frac{5}{8}"$ O. D.

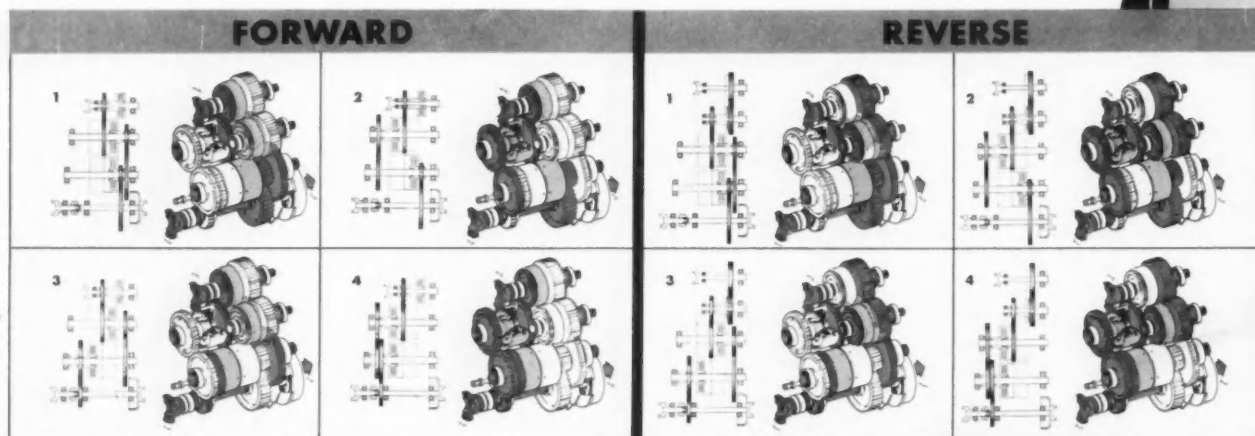


Bundy can mass-fabricate small-diameter steel tubing to solve a wide variety of design problems. The Bundyweld tubing shown is (1) expanded, (2) sheared and flattened, (3) expanded and slotted, (4) special formed and threaded, and (5) flanged.

**BUNDYWELD®
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4 Speeds Forward...4 Speeds Reverse FULL POWER SHIFT IN ALL RATIOS



New TWIN DISC TRANSMISSION

for engines in the 100 hp range

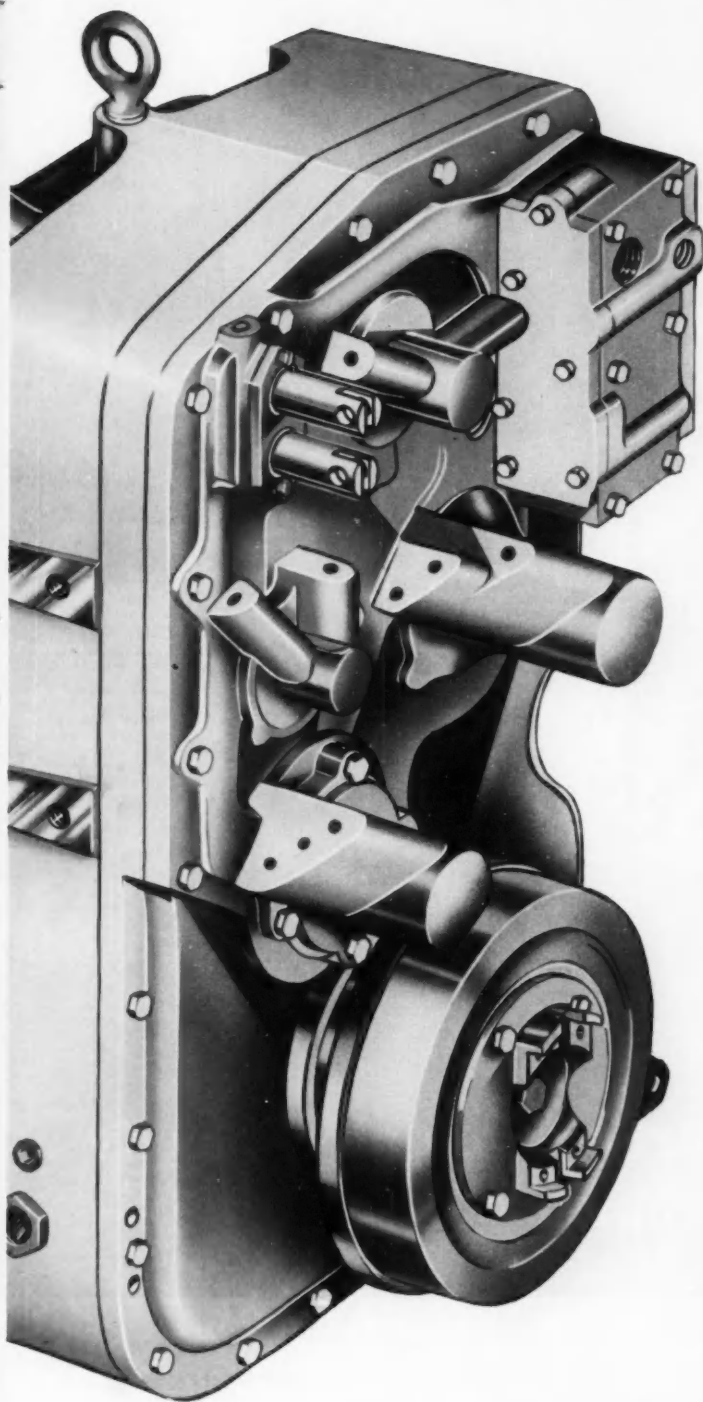
The Twin Disc "engine to axle" concept in OEM power transmission components takes another giant step forward with the introduction of the Series TD-44-400 Power-Sift Transmission. This new Twin Disc design is a four speed forward, four speed reverse box with full power-shifting in all speeds. Designed for engines developing from 75 net hp at 1800 rpm up to 108 net hp at 3000 rpm,* Series TD-44-400 includes two models

*This is rated horsepower delivery after power is taken off for auxiliary drives.

with an over-all ratio coverage of 6.91:1. Model TD-44-403 has ratios of 4.89, 3.19, 1.08 and .705; Model TD-44-404 has ratios of 5.98, 3.92, 1.32 and .866.

Simple design, positive operation

The complexities of planetary designs are avoided in the transmission's simple countershaft arrangement. Multiple-disc oil-actuated clutches energize the constant-mesh spur gear trains, while speed changes are effected by two



duplex clutches that function as range clutches.

Two large single-plate clutches handle the direction-changing job. These clutches, oil-cooled for maximum heat dissipation, act as the energizing clutches for all engagements.

Shockless clutching

Clutches are engaged by means of a cascade system of oil pressure regulation. A controlled pressure rise valve increases the pressure steadily and rapidly. This patented feature makes for exceptionally smooth clutch engagement.

The brake-regulated clutch release valve is ported for direct connection to the vehicle's brake fluid system. Thus, by depressing the brake pedal, the operator releases all clutches in the transmission, instantly cutting off the power source for vehicle movement.

Both ends of the output shaft feature yoke-type U-joint connecting members as standard equipment. Also standard is a parking brake and a disconnect jaw clutch on the output shaft. This jaw clutch may be engaged for four wheel drive or disengaged for single axle drive.

Easy servicing

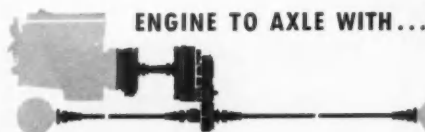
In designing the Series TD-44-400 Transmission, Twin Disc engineers have made easy servicing a prime requisite. Removal of the main housing cover gives complete access to all clutches and range gears. Anti-friction bearings are used throughout. The simple power train and relatively few parts can be readily appreciated when contrasted with the complex power flow and multiplicity of parts in a planetary gear transmission.

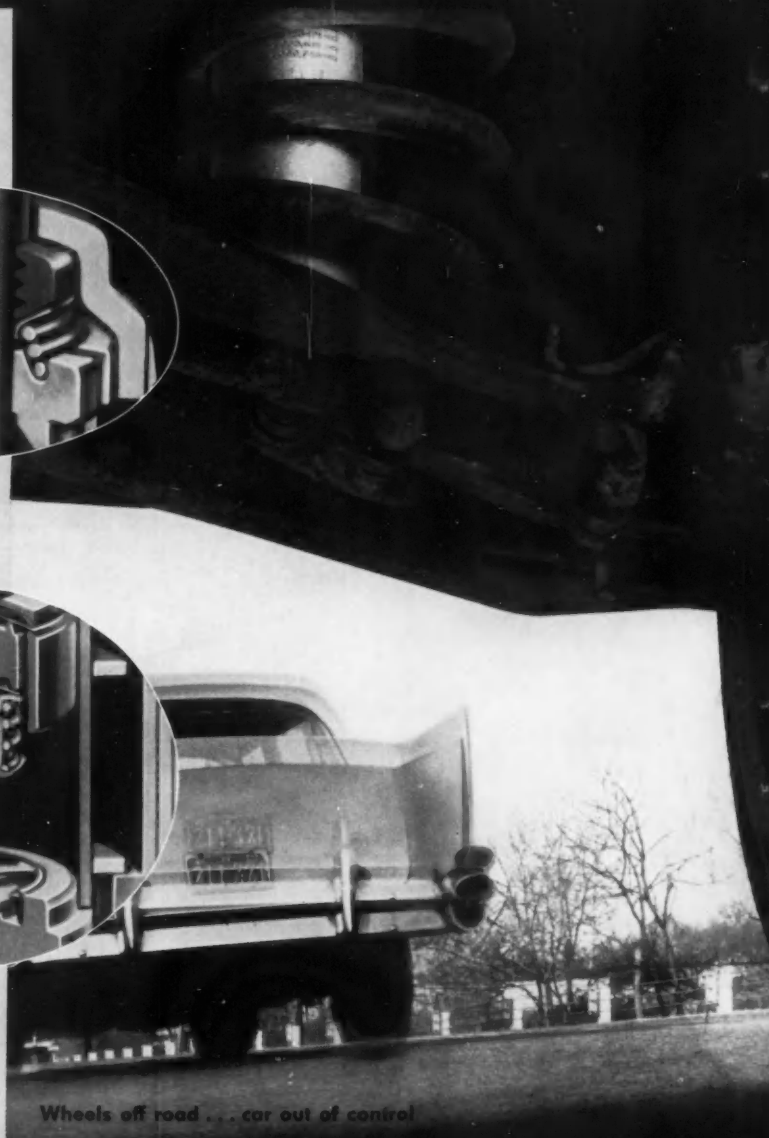
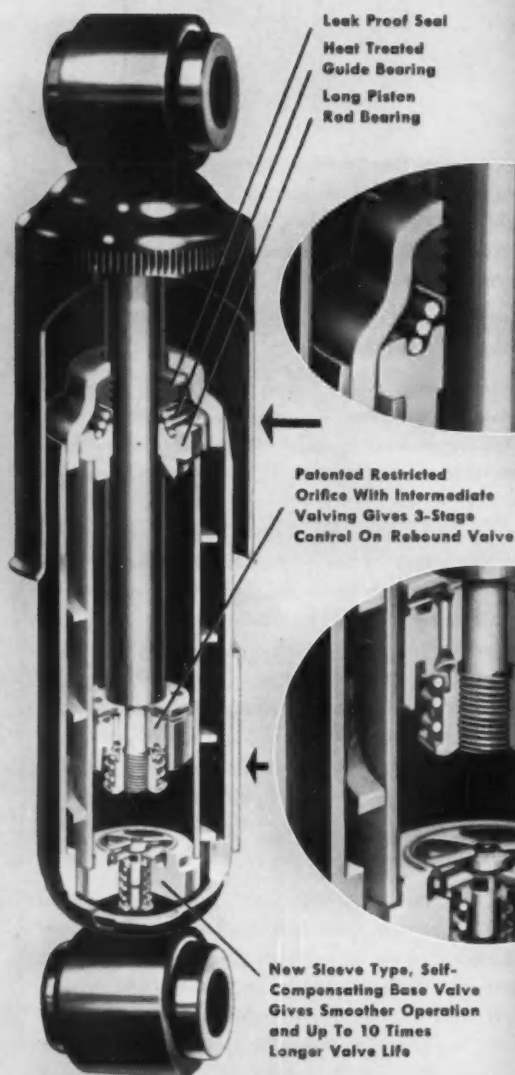
Torque converter-transmission package

The TD-44-400 Transmission is normally furnished with a Twin Disc Single-Stage Torque Converter as a package unit. The converter is a sumplex model featuring two power take-offs points. One is normally used for power steering. The other incorporates an SAE "C" pump mounting suitable for hydraulic power pumps.

Series TD-44-400 is one of a complete line of converter-transmission packages being developed at Twin Disc's Transmission Division. Twin Disc engineers will be pleased to make recommendations for these units in your vehicle drive. Contact the Transmission Application Engineering Department at our Racine office.

TWIN DISC CLUTCH COMPANY,
Racine, Wisconsin; *Hydraulic Division*, Rockford, Illinois.





Wheels off road... car out of control

Whatever shock absorbers you now specify will probably be replaced by Monroe

Monroe shocks are the miles-ahead leader in shock absorber replacement sales. Why this decided preference?

Ask professional racing drivers, and they'll tell you only Monroe delivers the sensitive, sure-footed control needed to clinch races like the Indianapolis "500". Ask knowledgeable, safety-conscious motorists, and they'll tell you no other shocks provide the road-hugging stability and safety of Monroe.

It's more than likely that car owners will replace the shocks you're now specifying with Monroe when the time comes. Why not give them their preference from the start? Our engineers will be glad to give you facts about Monroe superiority.

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MONROE AUTO EQUIPMENT COMPANY • Monroe, Michigan • World's Largest Maker of Ride Control Products
POWER STEERING • SWAY BARS • TRACTOR SEATS • SUPER LOAD-LEVELER® (stabilizing units)



For Sake of Argument

Where Do We Go from Here?

Retirement poses vocational problems at least equal to those of starting to work for the first time.

The boy about to begin work and the man about to retire have this in common: both are approaching a land they have heard much about but visited only fleetingly. Each may have read guide books or toured the land in flights of fancy. But neither is sure of the reality of what he envisions. One knows as little about work as the other does about loafing.

An oldster's selection of his post-retirement activity is likely to contain the seeds of its own growth or decay.

Physical comforts touch a small part of his problem. Recreation, entertainment, good old-fashioned loafing are stimulating respites from work. As permanently satisfying substitutes for work, they are nearly worthless.

Hobbies, as such, are almost in the same class. Only when they become avocations — alternate vocations, work with some purpose — do they rank high as permanent helps to harmonious living.

The man who seeks stability in retirement through something to keep himself busy; to keep his mind off of loneliness — stands a good chance of not getting what he seeks. But if he looks for ways to be useful to something or somebody else, he may gain by indirection what he missed by direct attack. . . . A mind filled with projects, and plans, and hopes for making its talents useful and helpful has little space left for self-pity and dissatisfactions.

Vocational guidance usually is thought a young man's need. Oldsters oftentimes need it even more.

Norman E. Shidle



BENDIX HYDROVAC[®] POWER BRAKES

Lead the field
in three
important areas:

1. BIGGER PAYLOAD—Because Bendix Hydrovac Power Brakes weigh less, they permit hauling increased payloads—up to several hundred pounds *extra*. **2. LOWER PRICE**—Bendix Hydrovac Power Brakes cost *less to buy—also less to operate, less to maintain*. **3. BETTER PROTECTION**—Bendix Hydrovac Power Brakes have built-in standby safety; manual braking in case of power failure.

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chips

from SAE meetings, members, and committees

TEST FACILITIES for the nation's space projects take about 7 years to complete, from the original concept to production of usable data. Eighteen months of this time is generally spent for review and approval by the Air Research and Development Command, the Air Force, the Department of Defense, and the Bureau of the Budget. Congressional approval takes one more year. Another year is usually required to get the actual dollars. About six months is then spent in getting signatures on various contracts. Now 2½ years of construction can begin. Upon completion, 3-6 months of shake-down and calibration elapse before testing begins.

both temperature and humidity are controlled, and the missile is cradled on a unique suspension system. A hydraulic system will raise the missile container and lower the missile directly into the silo.

SPLASH NOT SMASH is what you'd hear if the Maritime Administration's new hydrofoil test vehicle hit a reef. Reason: the hydrofoil struts are designed to shear off in such an emergency dropping the hull into the water.

EXTERNAL SURFACE AREA of a 125-passenger supersonic transport is expected to be between ¼ and ½ acre.

\$100,000 WORTH OF GROUND TESTING can produce much the same information as flight tests costing \$100 million or more, says Brig. Gen. Homer A. Boushey.

Some 15 or 20 flights may be simulated in a test cell, in the space of a few days. Several months of work would be required at a missile range to get the same information.

Ground tests often yield valuable information which would escape detection in a flight test. Unexpected developments occurring in a test cell can be detected, but in a flight test telemetry acquisition of the significant data may not be planned, for lack of anticipation. Even if all modes of failure were recognized, it is impossible to provide telemetry links to give information on all possibilities.

CHUFFING AFTER PRESCRIBED BURNOUT could prove disastrous to a space launching. Chuffing (intermittent oscillatory burning) of the second-stage after separation of the third-stage, before the third-stage is ignited, might cause it to ram the third-stage. The resulting damage or deflection might cause mission failure.

LARGER THAN MOST TRACTOR-TRAILER COMBINATIONS IS THE TRANSPORTER-ERECTOR developed to haul the Minuteman solid-propellant IC missile across the country and lower it into its concrete underground silo—from which it can be launched at a moment's notice. This vehicle is over 63 ft long and weighs 100,000 lb, fully loaded. But it has been designed to travel over most of the nation's highways and bridges. Inside,

SUBMARINES AND SPACE SHIPS might not seem to have much in common, but, as the following table shows, a very interesting comparison can be made between habitability conditions in nuclear-powered submarines and the similar but generally more severe conditions aboard space ships.

Factor	Submarine	Space Ship
Number of men	Around 100	1 to ?
Time of isolation	Days to months	Days to years
Ease of return	Usually minutes	Hours to months
Water	Unlimited	Severely limited
Food	Unlimited	Limited
Recreation	Limited	More limited
Communications	Limited	Limited
Gravity	No problem	Unknown to serious
Power	Unlimited	Limited (?)
Supplies		
Weight	Unlimited	Severely limited
Volume	Limited	Limited
Heat dissipation	Easy	Difficult

"OF COURSE the Engineer is a Threat to Society"

says **E. J. Tangerman**
Editor, Product Engineering

Material drawn from an
SAE Central Illinois Section
Earthmoving Industry Conference Presentation

DURING the last million years, man has passed through the stage of ignorant primitiveness when he was beaten and cowed by the elements and most other animals, to one in which he can live better, go farther, move faster, stand extremes better, and endure more than any other animal. He can even talk, grow his own food, use tools, bend the forces of nature to his will. From a lone dweller, he has multiplied into a society animal. This he has done by evolving stereoscopic vision able to adjust to light values of million to one, opposed thumbs, and a threefold enlarged brain. Instead of the 250 cells of the ant's brain or the 900 of the bee's, ours have 13 billion, whether we use them or not.

Our society is stable, not static like that of the ant. We recognize eccentricity with a nice mixture of respect and condemnation, generally within limits that allow us to continue our evolution. We deride the scrambled egghead, but ultimately accept his discoveries.

Our society is stable, but also new in form in that it is increasingly technological. Science was born in ancient Greece — perhaps with Socrates asking questions. Engineering was born with the building of the Greek temples and the Egyptian pyramids on land — and with the building at Athens of ships at sea. It gained force and breadth when Galileo began to make things to prove his ideas.

Our achievements over nature and other animals are with the assistance of tools, latterly powered ones, which we've had for only 150 years. With them we multiply our power, only an eighth that of a horse, our speed, only a tenth that of the deer-fly. We are moving ahead on an accelerative curve, led by the men who convert scientific or philosophical ideas into workable and usable hardware — the engineers. To those among us who wish to retain the good old days, who insist that the good Lord would have provided automobiles for us if he'd wanted us to ride, who want our society to become static, we engineers are a threat, and a decided one. We're forever upsetting their applecart, jolting them out of their complacent ruts.

Now what is this threat, the engineer?

By engineer, I mean the man with the analytical turn of mind, the man who converts scientific ideas into hardware, the scientist with a sense of urgency, the man who answers the questions "What?" and "When?" while the scientist is answering "Why?" He's the man with the rubber mind, the man who "intelligently disagrees." If he's younger, he usually

"The engineer," Tangerman postulates, "is responsible for the gadgets that have made us soft, the income that has made us rich, the military and productive capacity that has made us first internationally. . . . The engineer is the last dissatisfied man; the one who is busily tearing up a world that would love to emulate the ant by becoming static. . . . He is a disturber of the peace, an irritant, a bur — the last of the pioneers."

"THE ENGINEER," says editor-engineer E. J. Tangerman, "knows that knowledge keeps like fish . . . that it must be shared or it will spoil.

"He knows that all you get for creativity is a time advantage; that the Chinese had it right when they used the same ideograph for "advantage" and for "disaster."

"He knows that design isn't a spectator sport; that you have to take part in it to get any enjoyment out of it. . . . And he knows that brains, like muscles, atrophy from disuse. Easy *doesn't* do it.

"You've got to be aggressive and progressive or you turn into a horse on a merry-go-round . . . do a lot of galloping but never go anywhere."

has at least one college degree, but that is no guarantee that he's an engineer—or a threat to anybody. Back in 1900, there was one such engineer to each 1800 people, by 1950 the ratio was 1:300, by 1980 it is expected to be 1:90 and in 2000 it will be 1:40. That means we'll have 3,300,000 engineers in the U.S. 40 years from now.

What is the peculiarity of the engineer? On examination we find that the engineer drifted into rather than selected his career . . . but that a number of factors contributed. He always had a driving curiosity, an itch to study and to understand things . . . and a tendency to analyze. He tended to be an introvert—possibly even anti-social. He was more interested in ideas and things than in people. Even now he chooses the home shop project instead of bowling; a book instead of television; a technical meeting instead of a movie; intense conversation rather than social chit-chat.

The engineer tends to be a seeker for flaws; a critic. He's the hardest man there is to sell anything to—because he insists upon asking questions and making investigations.

Even when the proposed purchase is outside his field, he's difficult—although he admits that he eventually collapses and buys what his wife wants, just as other males do.

He is likely to be conservative. Much of his training and his environment make him a "No" man. He is constantly seeking flaws, why things won't work.

Beware of the engineer's expert opinion. His trained mind insists whatever it is can't be done, won't work, or people won't buy it. This hampers his creativity. As his experience and knowledge increase he unconsciously avoids the violation of nature's laws. Some of these, of course *are* laws, but some are just believed to be. And the engineer is as exasperated as any other professional man when some lay neophyte suggests—or even proves—that the accepted law is wrong.

I can hear engineers thinking: "Who says I'm creative, and open-minded?" While my readers are heating the tar and plucking the feathers—

even seeking a rail that Abe Lincoln may have left—let me hasten to point out that creativity again is a word that means different things to different people. I sat in for three days at a meeting of some 70 research directors, who couldn't come up with a definition, although they did outline four great classes or levels. The first is Nobel prize or *genius*—discovery—level. Say a hundred Americans can do work at this exalted height. Ten times as many are capable of *innovation*, a hundred times as many as at the *invention* level. At the lowest level—*problem solving*—there are ten times as many again, say 100,000 men, mostly engineers. We all talk about level 1 and seek level 2 but settle usually for level 4 with some of level 3—inventions—thrown in.

Real creativity—making some new and basic adaptation of the forces of nature—is a function of individuals, not of teams, groups or committees . . . a function of intelligence, not of education or erudition. In fact, there are those who insist that the breakthroughs are made by men who don't know too much about the field. As some wag has said, they don't know enough to know it can't be done.

Industry has, in recent years, tended to hire engineers and house them *en masse* . . . then wonder why they become herd-bound.

As I. Nevin Pally, president of ITT-Federal Laboratories, said recently, an engineer under these conditions may "weave a cocoon of job security and fringe benefits and snuggle safely inside." He becomes a high-priced production worker instead of a technological aristocrat. He works for overtime pay; not because he cannot leave a difficult problem. He begins to seek refuge in anonymity; to have a guilt complex because he is working for industry instead of for a non-profit laboratory; begins to doubt he's a professional man at all.

I mention creativity only because it is so important; because it is so easy for an engineer to join the pack that cries it down. It is so easy to resent the driving curiosity, the independence of will, the unwillingness to accept the "laws" of nature

"OF COURSE the Engineer

is a Threat to Society"

... continued

and the agreed-upon explanations, the emotional immaturity that defies conformity.

WE FORGET that:

- "It is strange how prudent men walk cautiously into oblivion, while audacious men rush indiscreetly into immortality."
- Heinrich Schliemann, a shoe manufacturer, found Troy by the simple expedient of looking where the *Iliad* said it was!
- An automobile mechanic with optics as a hobby showed the scientists how to grind the 200-in. lens for Mount Palomar.
- A "crazy Greek" named Nicholas Christofilos — without proper education — beat our best scientists by four years on basic ideas in the synchrotron.
- A bank clerk named Einstein developed the theory of relativity and suggested there was something in the atom bomb idea.
- Novalis said: "Theories are nets; only he who casts will catch fish."

But let's get back to our self-analysis as engineers. The engineer is a packrat. He collects information and gadgets and ideas that he hopes — and fondly expects — to use some day. Unprotected against himself, he's becoming more and more conscious of the real meaning of such words as reliability, quality, value, and integrity, believing less and less of what he reads and sees in which they are lightly used. He's learning, in short, to live with and respect himself in spite of the mechanized society in which he lives and which he created.

This matter of ethics and morality is not one to be taken lightly. When I wrote an editorial under the title of "Is Your Morality Showing?" we were startled by the letters received commenting that this is the essential element in the professional man — morality — the element that can win him respect.

High morality and the professional approach are characteristics of the competent engineer. But what is the professional approach? Louis D. Brandeis, almost a half century ago, defined a profession as:

1. An occupation for which the necessary preliminary training is intellectual in character, involving knowledge and to some extent learning, as distinguished from mere skill.
2. It is an occupation pursued largely for others, not merely for one's self.
3. It is an occupation in which the amount of financial return is not the accepted measure of success.

There is, in these three points, a great deal of food for thought. They suggest why the engineer resists value analysis when it threatens quality as well as cost, why he resists advertising that makes unjustified claims, why his voice is heard more and more often in discussions involving the atom and hydrogen bombs, the airplane and missile, the sky satellites, even the power lawnmower. The engi-

neer is feeling his responsibility as a professional; he begins to realize that he is his brother's keeper, that he can be branded with the mark of Cain. He wants to make his designs not only foolproof, but damfoolproof.

He knows that it is economic and practical to design for intended use — to make his product last its intended life span. But he wants to do it as it was done in the legendary "one-hoss shay," so no part wears out before any other, so there's a little more value and satisfaction there than the buyer expects, a little margin of strength, or power, or life.

This attitude is, of course, a threat to management, particularly the comptroller. It means extra time and costs in producing a design, and extra costs in producing the product, direct denial of the doctrine of planned obsolescence. It demands alert, open-minded, far-seeing management, with eyes on integrity instead of the balance sheet. It means that management must accept authority, not merely advise.

This attitude on the part of the engineers also means that management cannot be well-meaning, fumbling, maternal, but must be efficient too. It means, in fact, that the engineer becomes a part of management, not just an employee. It helps explain why the number of executives who are engineers in the U.S. has risen from 33 to 40% in the last few years, and suggests still further increases — perhaps to the level of Europe's two out of three.

This attitude also presages the end of managerial Momism, the kind of management that never strains organization capacity, never allows anyone to think or take a chance — then wonders why the company collapses. Or the kind of management that hides its ideas and methods like chicks under its wings in the befuddled maternal belief that then they'll never grow up and go out into the world on their own.

Because of all these characteristics, or in spite of them, the engineer is in demand for public, as well as private office, is being regarded as the key to our confusing society. He doesn't like it, but accepts it as his duty. And his lay associates are as impressed with his analytical approach to problems as they are irritated by his lack of genteel finesse in dealing with them.

In spite of this, the engineer is the key to our current problems, the arbiter of our current development. Upon him we must depend for social and sociological advancement. It wasn't planned that way, I'm sure, but that's how our civilization has worked out. All the luxuries-become-necessities that characterize our current lives are his work, and engineering has far surpassed sociology, politics, economics and government in its recent rate of change and its influence on society.

The engineer realizes that he is riding a nightmare, that the current interest in him can collapse as quickly as it grew. He knows that Lord Keynes, the great economist, didn't recognize technological innovation as of any importance only 20 years ago. He knows that the Greeks began a technical civilization 2500 years ago, that they knew how the planets orbited, the shape of the earth and its size, and much more, but that their preoccupation with soft living made them easy prey for Rome.

All things considered, the engineer may not be as great a threat to society as society is to him.

Lincoln Continental driveshaft fits smaller package

Based on paper by

D. R. Veazy

Ford Division, Ford Motor Co.

THE 1961 LINCOLN CONTINENTAL incorporates a constant velocity double Cardan universal joint, recirculating roller bearing spline, forged end yoke, and rubber element. These features are designed to save space, allowing a reduction in body dimensions, and provide smooth operation. The smaller framework into which the shaft had to be adapted is indicated in Table 1. Here, package dimensions are compared to the 1960 model. The space savings accomplished by this design are indicated by the tunnel size comparison of the two models, as shown in Fig. 1.

Constant velocity joint

The final driveline configuration, illustrated in Fig. 2, has a high included shaft angle at the front, of 8 deg 3 min. This angularity prevented the use of a conventional single Cardan universal joint, due to the resultant vibration conditions. Instead, a constant velocity double Cardan joint is used to handle the angles and torque encountered.

This joint is illustrated in Fig. 3. It consists principally of two production type Cardan universal joints coupled with a centering device. It has been subjected to a 40,000 mile proving ground durability test without failure. A relubrication cycle of 6,000 miles has been recommended for customer usage.

The use of this constant velocity joint practically

eliminated the cancelling effect of the front joint on torsional vibration. As a consequence, the rear joint included angle is kept a low design value of 2 deg 37 min.

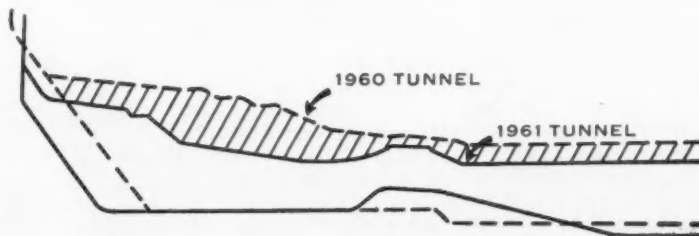
Taking up slip

Another point where increased road noise and harshness might be introduced into the power-train is in the provisions for slip. The answer in this design is the recirculating bearing spline design. The idea behind this is to provide for driveline length changes with a design having lower frictional characteristics under torque loading. These changes, called slip, are due to such factors as rear suspension geometry motion, longitudinal shifts of the powerplant on its mounts, and vehicle build variations. Normally, slip is taken up between the transmission output shaft and driveshaft slip yoke through the use of splines. This design is aimed at

Table 1 — Body Dimension Comparison

Exterior	1960		1961	
Wheelbase	131.00		123.00	
Maximum Length	227.15		212.41	
Maximum Width	80.30		78.60	
Maximum Height	56.70		53.51	
Interior	Front	Rear	Front	Rear
Effective Leg Room	45.92	46.17	45.60	41.53
Effective Head Room	39.77	38.19	38.40	37.71
Dash to Seat "A" Point	41.71	84.35	40.71	74.24

Fig. 1 — Tunnel size comparison of the 1960 and 1961 models. The redesigned shaft allows a smaller tunnel to be used to lend comfort to the basically smaller package.



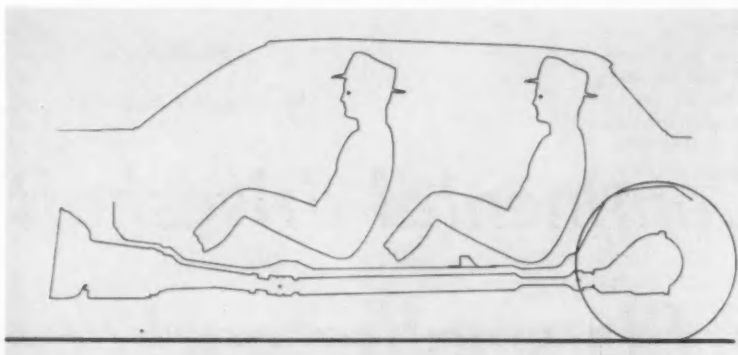


Fig. 2—The driveline configuration finally adopted has an included shaft angle at the front, of 8 deg 3 min. This resulted in the use of a constant velocity joint. This choice for a universal joint limits the rear joint included angle to 2 deg 37 min.



Fig. 3—Double Cardan constant velocity joint section. The joint consists of two production type Cardan universal joints coupled with a centering device.

Lincoln Continental Driveshaft

... continued

allowing these changes to be made more smoothly than, say, a rolled involute design might allow.

The recirculating roller bearing spline design is shown in Fig. 4. Two torque transmitting recirculating roller bearing assemblies slide in machined keyways machined out of the transmission output shaft. The bearings themselves are snapped over machined keys in the cast pearlitic malleable slip yoke. Proper control of the runout or wobble of the constant velocity joint assembly is achieved by three machined pilots in the slip yoke. These pilots are located at the forward end of the slip yoke and at each end of the bearing assemblies. They ride on the outside diameter of the transmission output shaft.

Production assembly of the driveshaft is facilitated by bell-mouthing the ends of the output shaft keyways and providing piloting tangs on the slip yoke. On assembly, these tangs, cast on the yoke ahead of the bearings, would hit the bell-mouthed surface of the keyway, rotate the driveshaft, and

guide the bearings into the keyways. To increase bearing life by better distributing the load, the sides of the keyways are crowned from the midpoint outward.

Rubber element

A torsionally resilient rubber element driveshaft, shown in Fig 5, aids in detuning the vehicle and suppressing axle gear noise. This helps overcome some of the noise problems presented by the unitized body. The resiliency of the rubber is also believed beneficial in reducing and cushioning impact loads due to transmission shifts. The design consists of eight rubber biscuits bonded on the inside diameter to the inner tube, with a friction fit at the contact with the outer tube. The greatest suppression of axle gear noise is achieved with a torsional rate of 1.5 to 1.9 deg per 100 lb ft.

End yoke

To provide an acceptable seating condition for the center passenger in the rear seat, a forged end yoke is used. This end yoke is shown in Fig. 6. It has a diameter of 1.44 in. and is 14 in. long.

▲ To Order Paper No. 320D . . . from which material for this article was drawn, see p. 6.

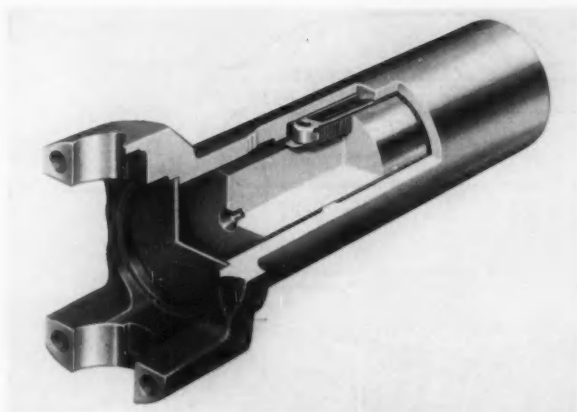


Fig. 4 — **Recirculating roller bearing spline design.** This design allows for changes in length of the driveline while transmitting torque. The lower friction of this spline limits road noise.



Fig. 5 — **Driveshaft rubber element section.** Not only is axle gear noise suppressed but it is believed to be beneficial in cushioning impact loads due to transmission shifts.

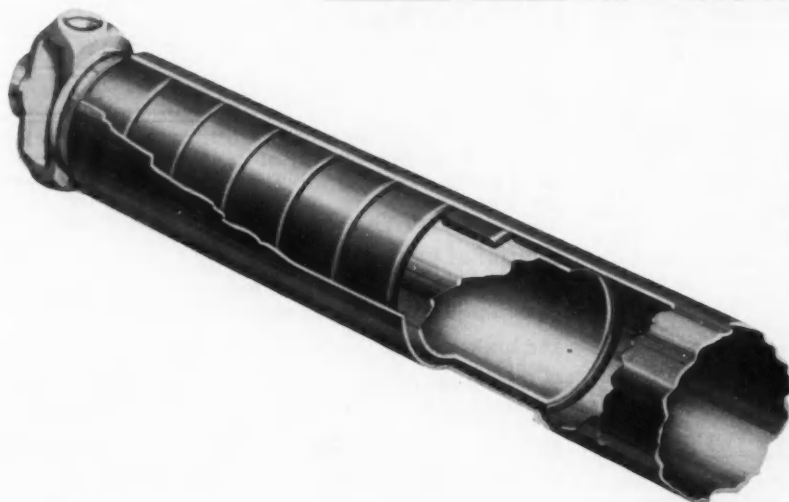


Fig. 6 — **The forged end yoke** is only 1.44 inches in diameter, allowing a better seating condition for the center passenger in the rear seat.

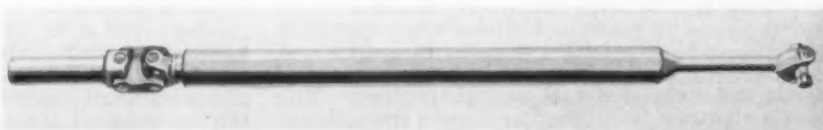
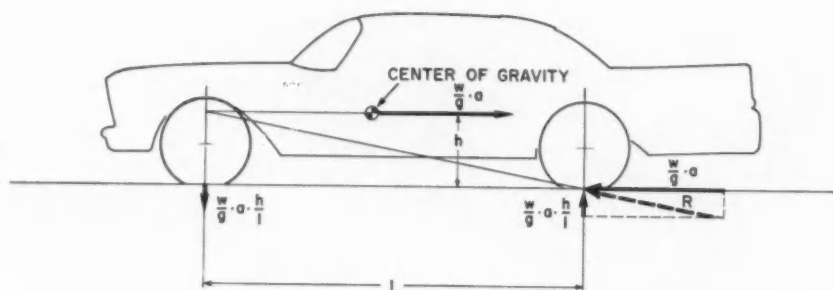


Fig. 1 — Dynamic forces applied during acceleration of a conventional rear-drive car with unsprung differential and brakes.



How to get

Big Car Ride and Handling in

Based on paper by

G. W. Gibson

Dodge Division, Chrysler Corp.

ENDOWING a compact car with the ride and handling characteristics of the standard-size car presents a challenge. A small car is inherently more sensitive to road irregularities, directional stability is interfered with in most designs because the distribution of the mass is closer together, and higher spring rates and stiffer suspension detract from the quality of the ride.

Perhaps the outstanding ride characteristic of the big car is the way it takes the bumps "flat," without pitching up and down. The flat ride depends (to a certain extent) on the relationship between the mass distribution of the car and its wheelbase and wheel rate or, in other words, on the polar moment of inertia of the spring mass, wheelbase and wheel rate. The large car has a relatively large length/wheelbase ratio; the small car a relatively small one because the designer tends to reduce overall length while retaining a relatively long wheelbase.

Causes of pitching

The principle of pitching can be understood by imagining a long board to be supported at each end by a coil spring. If one end of the board is struck, it will vibrate like a seesaw. If the two coils are moved toward the center of the board, the vibration will be slowed. In other words, the pitch frequency will be reduced. Similarly, adding weights to the ends of the board will further increase its polar moment of inertia and make it vibrate even more slowly. The slowest vibration is achieved by placing the support-

ing springs close together, adding weights to the ends of the board, and lowering the spring rate.

The Lancer is built with a 106.5-in. wheelbase and 189.3-in. overall length, giving it the highest length/wheelbase ratio of American compact cars. Putting the engine well forward in the body and moving the fuel tank, spare tire, and wheel as far to the rear as possible, gives it a high polar moment of inertia as well.

If the flat ride is to be maintained during acceleration and braking as well as under constant velocity conditions, pitching must be controlled. A careful attention to the geometry of the front and rear suspensions will control pitching but will not entirely eliminate it.

Control of pitching

Fig. 1 is a simplified free body diagram of a conventional rear-drive car with unsprung differential and brakes. The acceleration inertia force $\frac{W}{g} \cdot a$ acts at the center of gravity and at the rear wheels. The dynamic load transfer from the front to the rear is represented by the formula $\frac{W}{g} \cdot a \cdot \frac{h}{l}$. If the kinematic instant center of the rear suspension is located anywhere along the line of action of the resultant R of these forces, no displacement of the rear springs will occur under acceleration because the resultant force has no moment arm to apply a torque about the instant center.

Since there is no fore-and-aft force on the front suspension, we can do nothing similar with its geometry to prevent the front end of the car from rising under acceleration except to use a high front wheel rate as rebound. To reduce further, or even elimi-

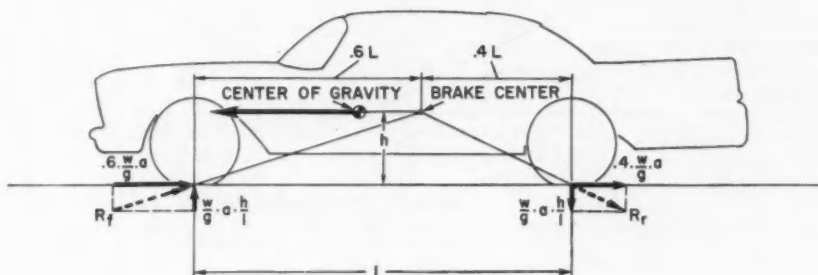


Fig. 2 — Dynamic forces applied during braking of the same car shown in Fig. 1, with brake torque distribution 60% front and 40% rear.

a Small Car

nate, pitching we can select an instant center location for our rear suspension above the neutral line so that the rear of the car rises with the front.

Fig. 2 shows the same car when braking, with a brake torque distribution of 60% front and 40% rear. Again, if the instant centers of the front and rear suspensions are located along lines of action of the two resultants, R_f and R_r , the car will stay at its normal static height under braking.

A compromise had to be made between the Lancer's attitude under acceleration and under braking. One must keep in mind the limitations imposed by the need to avoid too much change of wheel caster, which can introduce harshness. These limitations on front and rear suspension geometry complicate the handling problem because they can affect the selection of roll steer, roll axis location, and the physical location of suspension pivot points. Moreover, care must be taken that the control of attitude does not build into the car excessive tire scuff, brake hop, or power hop.

Designing for good handling

There are five requirements to be met if a car is to handle well. These are:

1. **Cornering ability** — capability of withstanding a maximum amount of lateral acceleration per degree of tire slip angle.
2. **Directional stability.**
3. **Wind stability.**
4. **Response to the driver.**
5. **Feedback to the driver.**

In the absence of complete tire data at high slip angle, the best measure of cornering ability appears to be the lateral acceleration per degree of slip angle. Thus, one tries to develop a car concept which al-

lows the tires to develop the maximum cornering force, or force per degree of slip angle, of which they are capable.

Assume a vehicle having its c.g. located at the ground, equal weight distribution, roll axis along the ground, a tire camber angle of 0 deg, no power applied to the driving wheels, and equal tire sizes and pressures. Actually, the c.g. is located somewhere above ground level and so dynamic load transfer to the outer wheels takes place during cornering, resulting in a loss of total cornering force of the four wheels at a given slip angle. This is because the curve of lateral force versus vertical load for a typical tire is convex and not linear.

Other sources of reduced cornering forces associated with the c.g. are the jacking effect of certain independent rear suspensions, unequal front and rear roll stiffness, and the nonhorizontal roll axis inherent in most automobiles. Since drive thrust must see a large share of the tire's potential reacting force, it subtracts considerably from the cornering force of the driving wheels, front or rear. Moreover, unfavorable camber of front and rear independent suspensions also detracts from cornering force.

Directional stability

The neutral steer line of a car is the line at which lateral forces applied to the car do not cause yawing. A symmetrical car, therefore, will have its c.g. and neutral steer line both located at the midpoint of the vehicle and loads and inertia forces acting on the c.g. will not cause yawing. The result is a neutral steering vehicle, which is undesirable because there will be a shifting back and forth from understeer to oversteer imposing an intolerable control situation on the driver.

To overcome neutral steering, the c.g. and neutral steer line must be separated. One way to do so is to move the c.g. forward or rearward. If moved forward, the neutral steer line follows but does not move quite as far because the outer tires, relative to vertical load, contribute less cornering force and the inner tires contribute more from that of a symmetrical car. The same is true in reverse, when the c.g. is moved rearward (Fig. 3).

When the neutral steer line is behind the c.g. the car will understeer and be directionally stable because the centrifugal force at the c.g., resulting from any deviation in course, will tend to counteract the effect of pivoting about the neutral steer line. Conversely, the oversteering car will be unstable because the effect of a side load ahead of, behind, or at the

Fig. 3 — Shifting the c.g. forward also moves the neutral steer line a little forward to give understeer. The reverse movement creates oversteer which is undesirable because unstable.

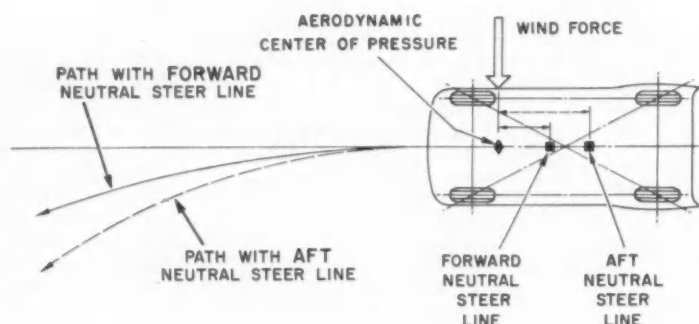
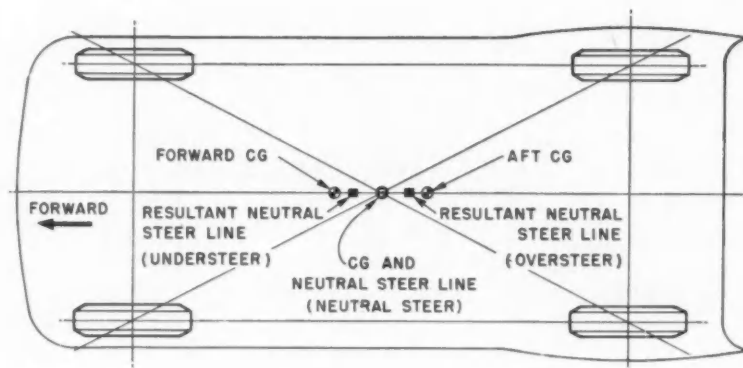


Fig. 4 — Effect of aerodynamic moment arm on the path of two different understeering cars. Stability is achieved by locating both center of pressure and neutral steer line forward of the midpoint with the center of pressure close behind the neutral steer line.

c.g. will be magnified by the centrifugal force. In the Lancer, there is an understeering characteristic to give easy driver control.

Wind stability

To achieve wind stability one must know at what point all wind side forces are acting on the car. This is the aerodynamic center of pressure. In most cars this pressure point is normally located close to the front wheels, ahead of both the c.g. and neutral steer line. This is undesirable because the wind force pivots about the neutral steer line to cause the car to rotate about this line. The result is yaw and side drift forcing the car to steer off the road in the same direction as the wind.

Fig. 4 shows that as the distance between the center of pressure and the neutral steer line, or the moment arm, increases the wind causes a greater variance from the intended path and driver correction is required. The center of pressure in the Lancer is located aft of and close to the neutral steer line. The first response to a wind force is to drift in the direction of the force, but the small differences in slip angles between the front and rear tires produce a steering angle which overcomes the drift and pushes the car across its original path.

Dynamic response

Proper dynamic response involves yaw, side slip, and roll. The yaw velocity response of a car to steering wheel displacement has to be high enough and free from overshoot so that precisely controlled travel along a selected path is possible for the driver. The yaw velocity is introduced by the steering angle needed to make the car follow the curved path. The yaw angle is required to bring the rear tires into a slip angle position at which they can develop their

share of cornering for a given lateral acceleration of the car.

The amount of the yaw angle and the time required to build it up and maintain it determine more than anything else whether or not the response and, therefore, control is satisfactory. Hence, in the Lancer, provision is made for a high yaw velocity response while striving for the smallest yaw angle for a given lateral acceleration.

Side slip can be ignored in this discussion, but roll is significant. Roll affects the speed of response even though it does not directly alter the car's path.

Overall response time can be shortened by using fast-responding steering effects which are introduced through the tires. Among these are unequal weight distribution, unequal tire size or pressure, roll axis inclined in the side view, and suspension deflection steer.

Overall response time is increased by the slow-responding steering effects of body roll. Body roll in the Lancer has been controlled considerably by proper damping. A steering wheel displacement pulse or step input should not introduce an objectionable roll oscillation before reaching a steady-state again.

Importance of feedback

Torque feedback through the steering gear gives the driver valuable information for the decisions he must make to keep the car in a safe path. As with most cars, the Lancer feedback is the self-aligning torque generated at the footprint areas of the front tires. Excellent feedback is provided by low mechanical and hydraulic friction in the wheel supports, steering linkages, and steering gear.

To Order Paper No. S281 . . .
from which material for this article was drawn, see p. 6.

NASA Researchers

conclude that the . . .

VTOL Transport

- should be kept as
simple as possible
- include only necessary
modifications

Based on paper by

R. E. Kuhn and M. O. McKinney

National Aeronautics and Space Administration

NASA researchers conclude, in a recent study, that fundamentally a VTOL transport should use a minimum of new concepts; and these should be kept as simple as possible. Only those modifications necessary to achieve VTOL performance should be included. This means that in the cruise condition the VTOL transport should be as much like current transports as possible, taking advantage of proven techniques to assure success. For the long range VTOL transport, emphasis on the VTOL end of operation must not overshadow the requirements for speed and efficiency. The importance of this is evident in the fact that for any mission having a radius of 200 mi. or more, over 95% of the operating time will be in the cruise configuration. For short range or extensive hovering requirements the helicopter will not soon be replaced, so major effort should lean towards improving cruise performance for longer range.

Some specific recommendations and comments encompassing these ideas include:

- **Design for maximum lift-drag ratio.**

This makes long range feasible and is more readily achieved with a long-span wing.

- **A long span with a good load distribution gives a safer configuration.**

With an engine out on a hot day, this design allows flight to continue at a much lower speed than

is possible with a short-span poor load distribution wing. In order to take off vertically under elevated temperatures or at high altitude, the installed power must be considerably greater than that required for hovering. Under these conditions, with one engine out, the aircraft would barely be able to hover on a standard day but not on a hot day. Therefore, the ability to continue flight at reduced speed is important.

Some hold that since the wing is not needed for take-off and landing it should be kept short to reduce parasite drag. This is a valid approach for high-speed sea level operation, but for operation at maximum lift-drag ratio the induced drag is equally as important as parasite drag, so wing span becomes a vital parameter. At altitude a long span gives lower fuel consumption and longer range.

- **To double the usefulness of the aircraft good STOL performance could be included.**

There is no substitute for vertical performance when it is needed; but often, clearings of several hundred feet can be found, even in the jungle. A considerably greater weight can be lifted with a rolling take-off, if advantage is taken of these short fields. STOL performance depends primarily upon the span and its efficient use, since the power required in the transition or STOL regime is almost entirely the induced power which is inversely proportional to the square of the wing span, for a given weight. This holds true throughout all but the low speed end of the transition. Thus, the required power drops more rapidly with speed if the span is greater. A good configuration for STOL performance is the long-span flapped-tilt-wing. This arrangement also has good span load distribution.

- **Flight at altitude is a requirement.**

This allows the conditions of maximum lift-drag ratio flight to be matched with a high cruising speed and efficient engine operating conditions.

- **Jet or propeller support for the VTOL transport is determined from consideration of the type of terrain from which operation is required, and also hovering time.**

The high downwash dynamic pressures from jet and turbofan supported vehicles have a much smaller number of possible sites than the lower disk loading devices. Also, a hovering jet has a very high fuel consumption. This would indicate that the more flexible, lower disk loading devices would be the best to use. But for combat use, or operation from well-prepared fixed bases where hover is required for short periods as an incidental part of take-off or landing, jets can be used.

- **Powerplant reliability is even more important than in conventional aircraft.**

Much time, effort, and money will have to be spent on developing a powerplant system having the highest degree of reliability. More extensive proof testing than has been done in the past will be necessary. One heartening point though, since the need for feathering and synchrophasing will be eliminated in the VTOL aircraft with cross shafting, the troublesome controls needed for these functions are dispensed with.

To Order Paper No. 337D . . .

from which material for this article was drawn, see p. 6.

WHAT'S AHEAD

in Soviet Civil Aircraft

The "Bounder"—a Mach 2, 4-turbojet bomber—will probably be the basis for Soviet supersonic commercial transport. Emphasis also being placed on VTOL.

Based on paper by

Donald J. Ritchie

Research Laboratories Division, Bendix Corp.

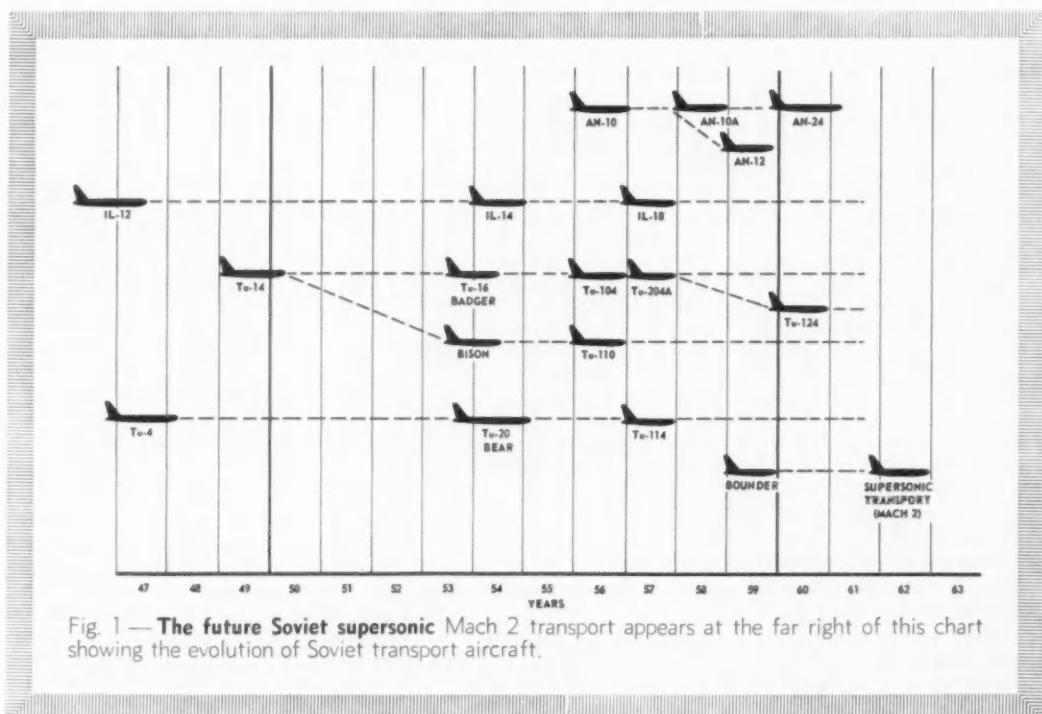


Fig. 1—The future Soviet supersonic Mach 2 transport appears at the far right of this chart showing the evolution of Soviet transport aircraft.

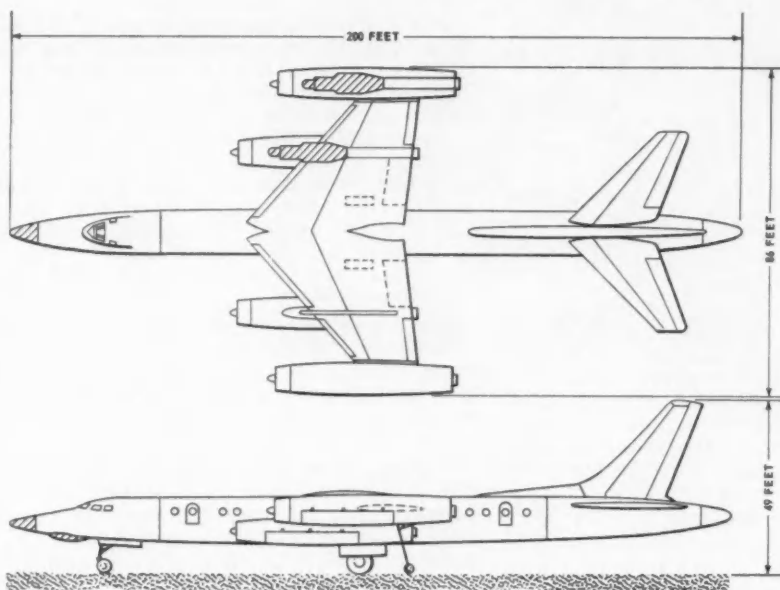


Fig. 2 — Author Donald L. Ritchie's concept of a 75-passenger version of the Soviet's Mach 2 BOUNDER bomber. It carries four turbojet engines, each with 37,000 lb thrust.

If future Soviet aviation progress follows the pattern of its past, the Russians undoubtedly will attempt to produce a supersonic jet transport well ahead of the United States' and other Western successes. This is indicated by the way Soviet writers are pursuing the problems of design and operation of supersonic transport.

The future Soviet supersonic commercial transport probably will be a modification of the new 4-engine Soviet supersonic bomber, BOUNDER (See Fig. 1).

Much less likely candidate for conversion is the Soviet BACKFIN or Yak-2, a supersonic Mach 1.28 bomber. It offers little hope of conversion because it carries its side-by-side engine installation within the rear portion of the fuselage. Thus, no room is left for either passengers or freight.

The BOUNDER's four, 37,000-lb thrust turbojet engines, on the other hand, are pod-mounted. Two are mounted on the wing tips; two are slung under each wing. The fuselage is left clear.

The BOUNDER — which came into being in late 1959 and early 1960 — is a Mach 2 aircraft, designed probably by either Yakovlov or Il'yushin. Its engines are probably improved versions of the Mikulin AM-3 engine.

The military version of the BOUNDER is a mid-wing airplane with the wing carry-through structure passing above the bomb bay. In the civilian version, because of the pod-mounted engines the

Soviet civil aviation has had a phenomenal growth. Starting in 1945 with almost no modern commercial aircraft, it now compares — only 16 years later — with aircraft and operations somewhat comparable to Western world developments.

This speed of development is probably due as much as anything to the complete freedom of communication and excellent sources of information on world aeronautics established in the Soviet Union. Information is gathered and disseminated through official agencies such as the VINITI.

In the Soviet Union, Tupolev does not hide his designs from Il'yushin or Antonov, any more than he does from Yakovlov. The headquarters of Soviet aircraft construction is a unity. Besides, very onerous research is undertaken without the slightest hope of immediate profit. This makes the career of a research worker very attractive.

WHAT'S AHEAD in Soviet Civil Aircraft

... continued

design could undoubtedly be modified to a high wing design, allowing the wing carry-through structure to pass above the passenger cabin. This arrangement would also lower the fuselage and allow more easy access for passengers.

Fig. 2 shows the author's concept of a supersonic Mach 2 transport modeled after the BOUNDER. An 11 ft 6 in. diameter fuselage would probably accommodate 4-abreast seating quite comfortably.

Considering the operational date of the BOUNDER, it is possible for the Soviets to have a civilian counterpart of this aircraft operational in 1962. Such an aircraft could carry in the neighborhood

SOVIET AIRCRAFT do not exceed comparable U.S. aircraft in performance, Author Ritchie says.

Specific fuel consumption is higher on Soviet planes in almost every case. Control surfaces are not powered, in keeping with the general Aeroflot belief that mechanical control linkages should be used when possible. Water injection has been dropped completely because of weight and service difficulties.

of 75 passengers for ranges of about 1500 nautical miles with an operational altitude of 50,000-60,000 feet.

The BOUNDER modification would be very similar to the Convair transport version of the B-58, designated the Convair 58-9, which would fly first in October 1963, perhaps a year later than the introduction of the civilian BOUNDER. The configuration of the 58-9 would be similar to the BOUNDER, even including wingtip engines. The 58-9, based on work already done by Convair on the B-58C, would travel at Mach 2.4, carrying 52 passengers, two abreast, over a stage length of 2170 nautical miles. It would be powered by four P & W J58's of 33,000 lb dry thrust each and would have a take-off gross weight of 190,000 lbs.

Further Soviet articles reveal that some Russians are seriously considering the design of new supersonic transports. Fig. 3 shows several futuristic transport designs conceived by Russian engineering student A. Zhigarev of the Moscow State University and by engineer D. Pipko.

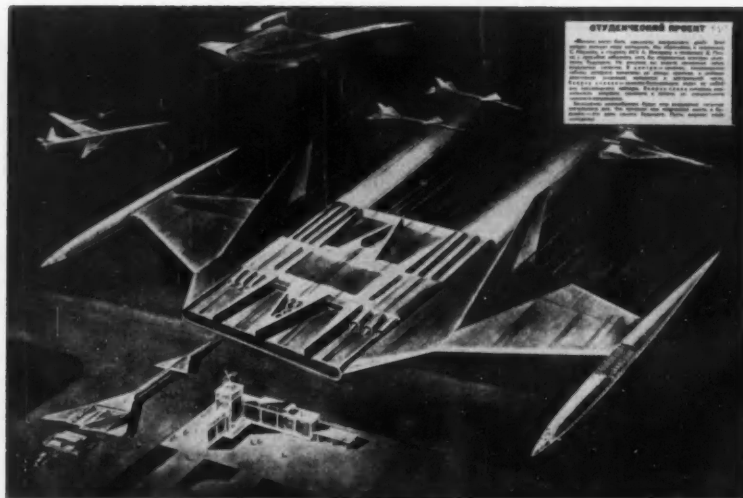
Recent Soviet literature also indicates that emphasis is being placed on slow and vertical take-off aircraft. The Soviets do not have an extensive network of prepared airfields, and it would be a great breakthrough to be able to go in and out of unprepared fields in their exploitation of the vast expanse of Siberia and other undeveloped areas. In this regard there seems to be a trend to very large turbine-powered helicopter type aircraft.

Finally, it is doubtful that the Russians will produce a nuclear transport aircraft before a military version has seen a few years of operational service to solve the many problems inherent in such an aircraft. After the perfection of the military version, there is little doubt that the GVF (main administration of civil air fleet) will profit by the nuclear-powered transport by incorporating a modification of it into *Aeroflot*.

To Order Paper No. 345A . . .

from which material for this article was drawn, see p. 6.

Fig. 3 — Futuristic transport design conceived by a Soviet student (taken from *Tekhnika-Molodezhi* of July, 1960).



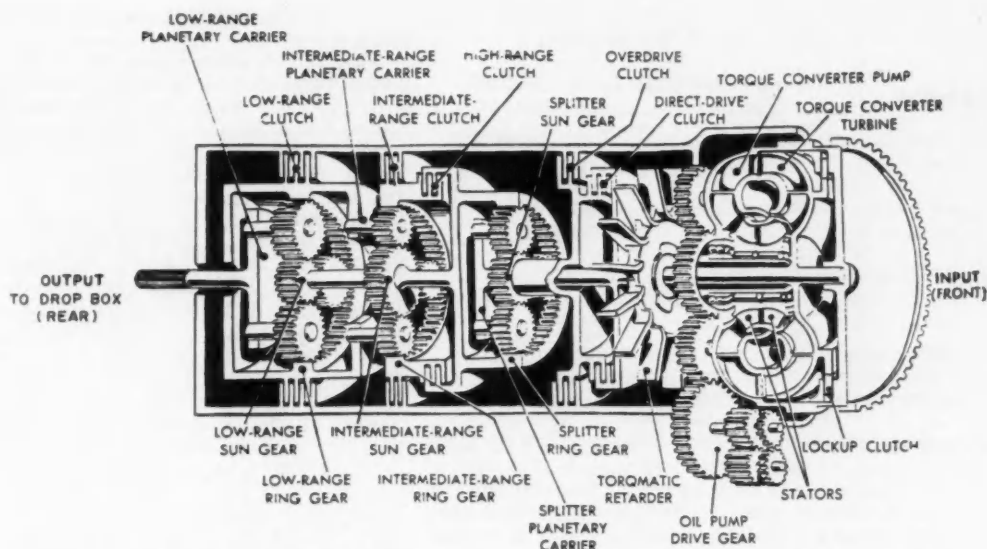


Fig. 1 — Diesel Hydraulic transmission. This unit provides for torque conversion, speed ratio changes, and power distribution. Inherent in this unit is the control of slip and load.

Diesel Hydraulics and Diesel Electrics Compared

Diesel Hydraulics are already operating in Canada and entering service in the U.S. What advantages do they have to offer over the long-in-use Diesel Electrics? Some are discussed in this paper.

Based on paper by
H. E. Martin
General Motors Diesel Limited

THE introduction of large Diesel Hydraulics on two American railroads will bring savings in weight and offers simplified maintenance. (This last item is especially important for foreign roads where electrical trades are often in short supply). Also, studies show good performance for the Diesel Hydraulic locomotive, with a more than adequate range and acceptable efficiency.

As good as the maintenance and reliability record of the Diesel Electric is, the Diesel Hydraulic transmission can potentially top it. There are no in-

herently fast wearing parts such as the motor and generator brushes, and, being sealed, environmental conditions are not consequential. Also, the Diesel Hydraulic needs no periodic cleaning.

HOW THEY COMPARE

COMPONENTS: Both the Diesel Hydraulic and Diesel Electric transmissions handle the engine output from the flywheel to the rails. Using different sets of hardware, both systems do the job by performing the following functions: torque conversion, speed ratio changing, and power transfer or distribution. The components of a representative hydraulic transmission are shown in Fig. 1. These can

be compared, function for function, with the components of a Diesel Electric transmission.

Function	Diesel Hydraulic Component	Diesel Electric Component
Torque conversion	Converter	Main generator and traction motors
Speed ratio changes	Planetary gear unit	High voltage control
Power distribution	Shafting and transfer gearing	Wiring

Both systems use final drive reduction gearing. For the electric system, only a simple spur gear set need be used at each of the axle hung motors.

PERFORMANCE: The ability of the Diesel Hydraulic transmission to work at higher values of adhesion is a major advantage claimed for it. The importance of this is, for the same assignment, the Diesel Hydraulic can be appreciably lighter. Fig. 2 is an adhesion/speed plot for both types of locomotives showing values for the Diesel Electric to be 20%

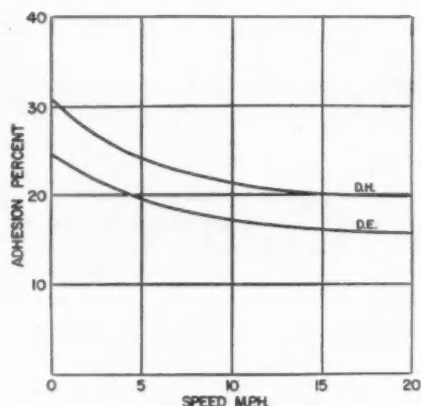
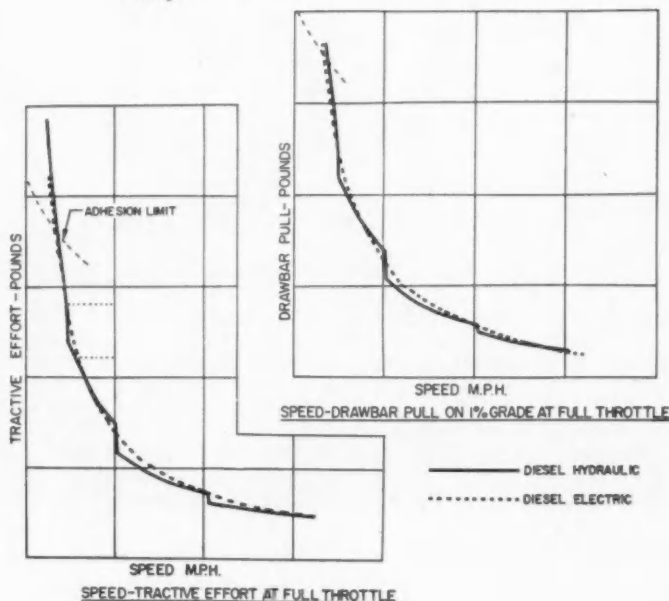


Fig. 2 — Adhesion compared. The better adhesion of the Diesel Hydraulic, due to all the axles being geared together, allows the locomotive to be lighter. The factor preventing slip for the Diesel Hydraulic is the weight of the whole truck. In the conventional Diesel Electric, this factor is the weight on the lightest axle.

Fig. 3 — Both units can develop high tractive effort at low speed but drawbar pull for the Diesel Hydraulic is better. This is because the lighter locomotive introduces less friction and mass to be overcome.



lower. It follows that the Diesel Hydraulic can be 20% lighter.

The better adhesion is due to the fact that the factor preventing slip in the Diesel Hydraulic is the weight of the whole truck, whereas in the conventional Diesel Electric it is the weight on the lightest axle. These different characteristics are not the result of any special capabilities of the hydraulic transmission; rather, they are due to the axles of the Diesel Hydraulic being geared together, while the conventional Diesel Electric's axles are independently powered. As a result, weight shift in the Diesel Hydraulic does not introduce instability. Weight shift between the truck axles is caused by the couple produced, at high tractive effort, by the differences in level of the points of power application and the coupler. The result is a transfer of weight from the leading to the trailing axle in each truck.

Both diesel types have the ability to start and accelerate heavy trains since they can develop high tractive effort at low speed. Illustrating this are the curves of Fig. 3, where plots of tractive effort/speed and drawbar pull/speed are shown. The curves for both types of units show the hyperbolic shape typical of a constant horsepower output. The discontinuities in the Diesel Hydraulic curve occur at the shift points. Tractive effort decreases at these points because of shifting from a point of full engine horsepower output and peak converter efficiency to a point of lower output and efficiency.

The tractive effort of the Diesel Electric is more limited than that of the Diesel Hydraulic, due to the cumulative effects of heat in the forced air ventilation cooled traction motors. As a result, limited time operation should be observed between the two short broken horizontal lines of Fig. 3. Continuous operation above the lower line generates heat faster than it can be dissipated to maintain a satisfactory insulation temperature in the traction motors. For comparison, the continuous rating for the Diesel Hydraulic, set by torque converter oil temperature, is off the top of the chart. This is ensured by the effective oil to cooling system water heat exchanger. The top line is the quarter hour time limit rating. Fortunately, full utilization of short time ratings is seldom required in railroading today.

When it comes to figuring drawbar pull the lighter weight of the Diesel Hydraulic is advantageous. This is because the locomotive must overcome its own rolling friction as well as haul its own mass up the grade. Under these conditions the operating efficiency is about equal to that of the Diesel Electric.

CONTROLS: Control of wheel slip in the Diesel Hydraulic is inherent, but not so for the electric transmission. In the Diesel Hydraulic the wheels are always in a direct circuit to the engine. Therefore slip is limited, since the engine drops power completely when governor speed is reached. On the other hand, the Diesel Electric is not sensitive to traction motor speed and needs a control to tell it when to drop power. Without this control the unloaded traction motor can run away, with destructive results. The correction of small slips below the control sensing proportion is not as good as the Diesel Hydraulic's inherent control, because one slipping motor tends to shift power to the non-slipping motors. In the Diesel Electric, the sensitive equilibrium existing under this operating condition is more likely to be interrupted by a power surge. This may partly account for the rail holding ability of the Diesel Hydraulic at the point of maximum available adhesion.

Concerning dynamic braking, the Diesel Electric has the advantage of being easily and automatically controlled. Also, it is smooth. The Diesel Hydraulic Torqmatic brake has more low speed capacity, and down to a very low speed, but automatic control will be difficult. Manual control is presently used.

The dynamic braking characteristics of both systems are shown in Fig. 4. In the Diesel Electric system the electrical energy is dissipated to the atmosphere at a high temperature, from roof mounted resistance grids. The amount of braking available is indicated by the dotted lines. The solid line curves define the operating limits of the hydraulic retarder of the Diesel Hydraulic locomotive. In this system, as speed decreases it is necessary to shift down. In order to avoid severe drive line shocks when doing this, the Torqmatic brake must be pumped empty then refilled after the shift is made. The entire operation takes less than 10 sec.

Load control, a protective function which guards against overload while maintaining maximum engine horsepower, is much different for the two systems. This control is accomplished in the electric system by using separate excitation, operating through the governor, to supplement the self excited field. Full throttle engine horsepower can be produced over the entire transmission speed range. This control is automatic and effective, but not inherent. In the Diesel Hydraulic system, engine control is built into the converter. This control is inherent and completely free of outside influences. Because the engine speed varies throughout each gear range, full throttle horsepower is obtained only at the top speed end of each gear range. An average of about 97.5% of full engine horsepower can be produced over the entire transmission speed range.

EFFICIENCY: At full throttle the transmission systems of the two locomotives have nearly equal efficiencies. The hydraulic transmission efficiency

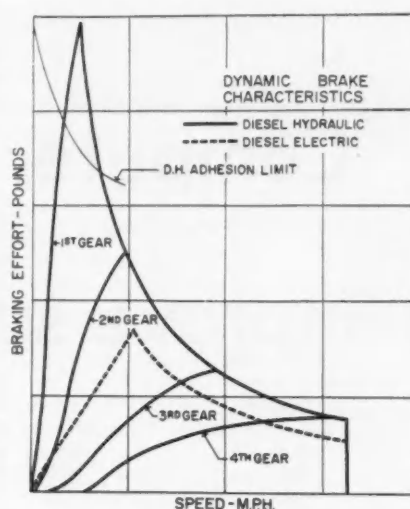


Fig. 4—Dynamic braking of the Diesel Electric is smoother, easier, and automatically controlled. The Diesel Hydraulic Torqmatic brake, however, has more low speed capacity, down to a very low speed.

improves as load is decreased. This is true down to $\frac{1}{3}$ load which is the lowest point for which data was available. This improvement is only slight at the high speed end and is a maximum in low gear. The electrical transmission holds its efficiency down to $\frac{1}{2}$ load and begins to decrease below $\frac{1}{2}$ load in the upper half of the speed range.

To get the whole story of efficiency the transmission and the engine must be considered as a unit, because, at partial load each of the two transmissions affects the engine differently. Since there is no fixed speed relationship between the generator and traction motors of the Diesel Electric system, the engine can run at reduced speed under partial load regardless of locomotive speed. The engine specific fuel consumption actually increases at lower speed and horsepower. But the engine driving a Diesel Hydraulic transmission must have a direct speed relationship with the locomotive. At high locomotive speeds, then, the engine must run near top speed. The fuel consumption down to $\frac{1}{2}$ load, in the high speed range, stays about equal to the full load value. Therefore in the high speed range the Diesel Electric has better partial load efficiencies, running about 5% better than the Diesel Hydraulic. In low gear, at partial load, the Diesel Hydraulic maintains a small advantage.

RANGE: The transmission range, expressed as a percentage, is 83% for the Diesel Electric and 92.5% for the Diesel Hydraulic. These figures are based on the definition that range is the portion of the total speed span over which full throttle operation can be used continuously. A high value means that the locomotive can be both a workhorse and a racehorse. Top speed can be higher without sacrificing low speed pulling performance. This is important where both steep grades and long level runs are encountered.

To Order Paper No. 291B . . . from which material for this article was drawn, see p. 6.

Computer studies stability to improve suspension design

Based on paper by

**F. N. Beauvais, C. Garelis,
and D. H. Iacovoni**

Ford Motor Co.

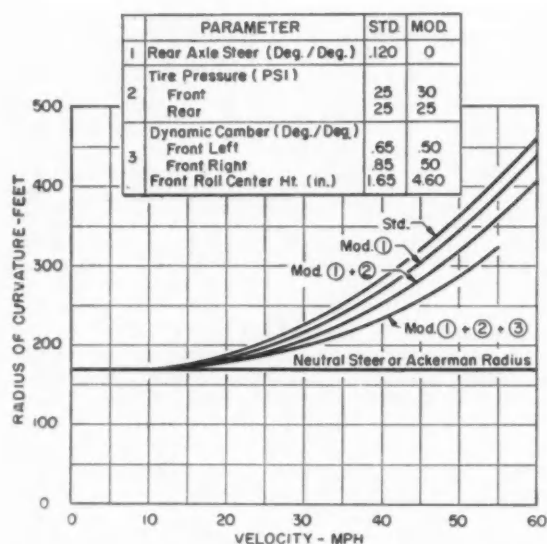


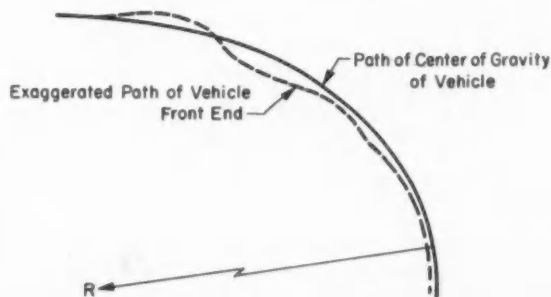
Fig. 2—Influence of various parameter changes on steady state radius of curvature response. The changes that were made are quite feasible and demonstrate the utility of this approach to vehicle design.

THE good correlation as regards cornering ability shown recently between a mathematical vehicle model and an actual vehicle, points up the vast saving available through computer use in designing. As refinements are added to the vehicle analog, this study revealed, a wider range of operating conditions can be studied in greater detail. Further study and understanding of the vehicle-driver relation, will enable the determination of the most desirable vehicle steer properties.

An example of the mathematical model's ability to predict what the actual vehicle will do is shown in Fig. 1. Here, the computed and experimental steady state and transient yawing velocity response are plotted. Such factors as the distribution of cornering forces between inner and outer wheels, during a transient maneuver, can be evaluated. Also, the influence of front roll bars on steady state radius of curvature response, can be predicted. Parameter changes such as tire pressure, camber, and suspension geometry, can readily be made to see the effect on the vehicle's response characteristics. Fig. 2 shows how this procedure can be used to predict the effect on understeer of several parameter modifications.

In the study of vehicle-driver relations, transient

Fig. 3—Path of understeered vehicle during a transient maneuver. The visual detection of lateral front end motion of the vehicle relative to the road may cause excessive corrective movement. This motion is a function of side-slip response, and may influence driver evaluation of the vehicle's handling characteristics.



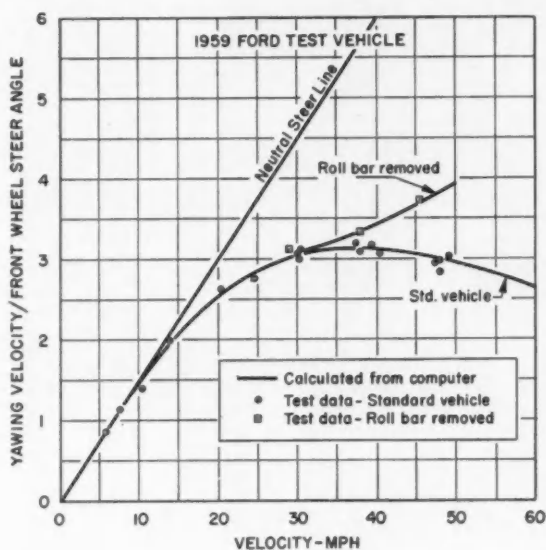
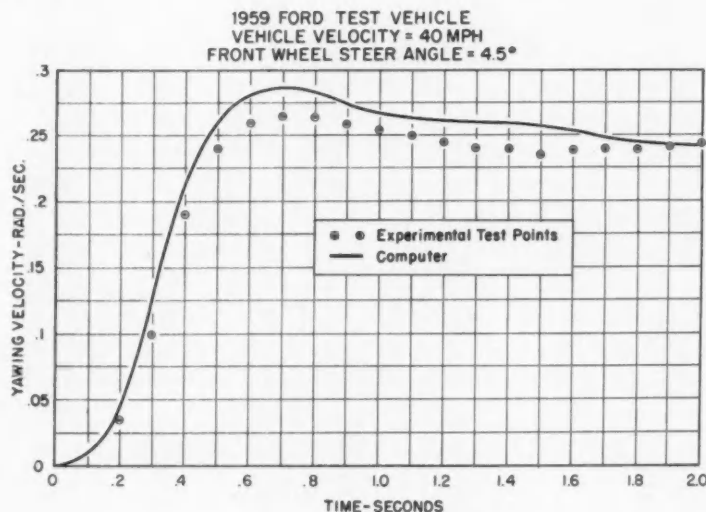


Fig. 1 — Correlation of computed and experimental yawing velocity response. Steady state response is shown in (a) and transient response in (b). Improvement of the mathematical model of the vehicle will extend the usefulness of computers in this application.



response is a primary concern, since a vehicle is almost always in a transient condition. Just which variable of vehicle motion is used by the driver as a principle performance index, must be discovered.

Preliminary investigations indicate that the driver is highly sensitive to the yaw mode of motion. This motion is apparently sensed visually from the lateral velocity of the front end, relative to the road, which results from vehicle rotation about its center of gravity. This effect is illustrated in Fig. 3, where the path of a typical understeered vehicle is shown, as the vehicle's center of gravity traverses a smooth path. This characteristic was determined from computer studies. The magnitude of this motion approaches $\frac{3}{4}$ ft, and is a function of the time rate of change of the vehicle side-slip angle. Excessive

overshoot or oscillation of the side-slip angle response will thus give the driver an uncertain sense of directional control and result in excessive corrective movements. Although this reasoning awaits conclusive proof, side-slip appears to be of prime significance in the driver's judgment of the vehicle's handling characteristics.

Work is currently in progress to further explore the vehicle-driver relation, and also to refine the mathematical simulation of the vehicle. The effects of traction, braking, and the dynamics of the steering system are hoped to be incorporated into the model. The steering system is of special interest in high-speed, straight-line stability.

To Order Paper No. 295C . . .

from which material for this article was drawn, see p. 6.

New approach to
body surface development

Slashes die model construction time

Based on paper by

R. Terry and R. Leasia
Creative Industries of Detroit

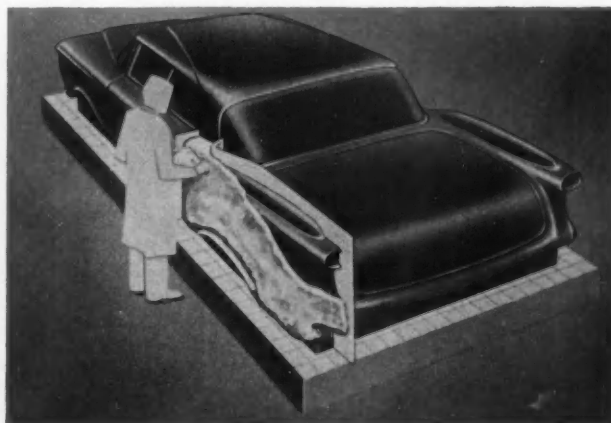
A new technique for body surface development reduces to one the number of steps between a clay model and a final approved 3-dimensional master model.

In far less time than with conventional practice, the body design department has final approved master templates from which it can trace out section and flowline information needed for layout requirements. This saves many man-hours and assures complete accuracy of the body design.

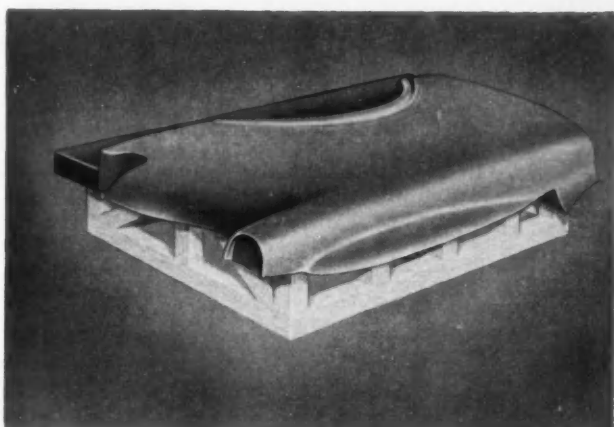
All information being recorded is traced from templates taken from approved 3-dimensional surface, allowing immediate start on developing flange, hole, and cutout information. Work begins concurrently on structural items, saving months over old techniques. Requirements for overall engineering design are cut significantly. This drastically shortens clay model to tooling cycle time.

On the following pages, this new shortcut method is illustrated by stages.

Method begins with normal clay model built to outside of metal with package dimensions and body cut lines established. Model can represent one complete body style or a two-door on one side and four-door opposite. Fences are established along appropriate body cut lines, and female molds of either plaster or plastic are fabricated against clay surface. Reference body inch lines are inscribed on molds for later alignment.

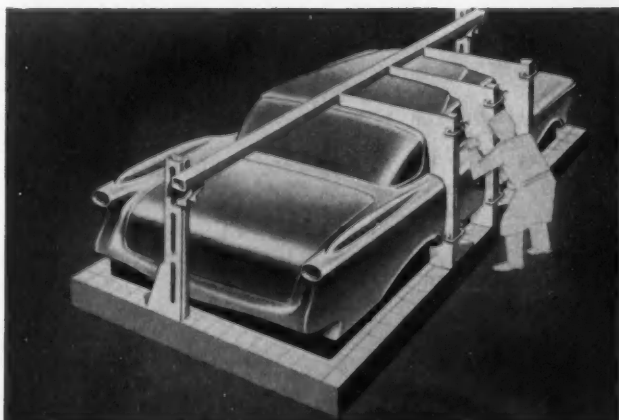
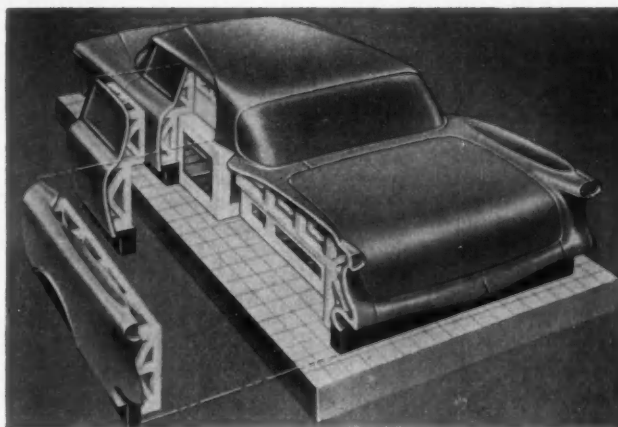


MOLDS are faithful reproduction of clay model. Epoxy resin is troweled into individual female molds. Resin retains stability of plastic but can be handled like wood. Adhesive characteristics enable as little as 0.005 or as much as 0.5 in. to be added to old surface with homogeneous bond.



BASE FRAMES are established to cube dimensions and bonded to male form as it cures in mold.

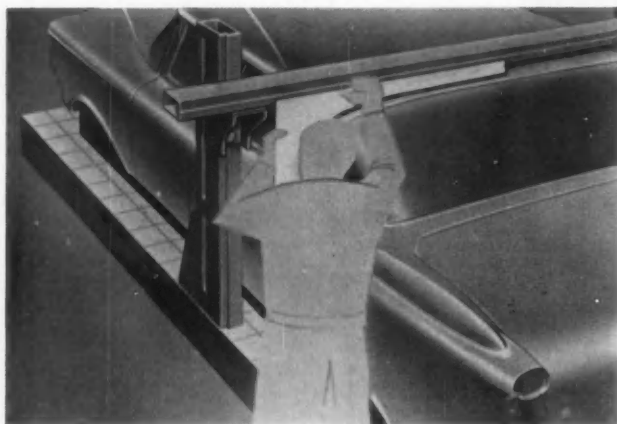
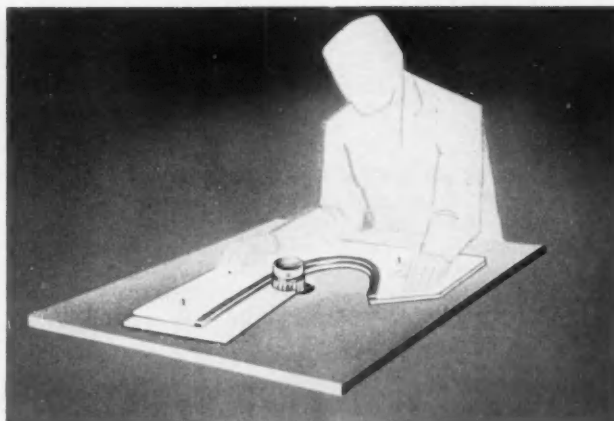
AS EACH male mold is removed from female, it is reconstituted into car position as a master body cube. This die model stack is identical to original clay model from which female molds were taken. Surfaces are then fared to proper condition. Exterior skin models are now complete on one side.



TEMPLATES are now fitted to approved model surface for both section and flow line. They can be fabricated by the conventional method, or rough cut to approximate surface contour, faced with workable plastic, and squeezed against model surface. This method assures positive fidelity to surface dimensions from model to template.

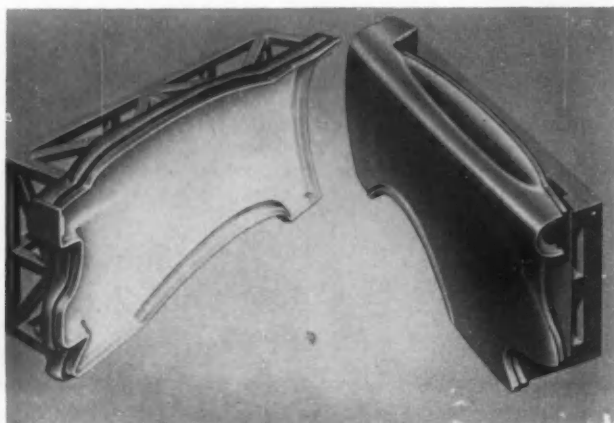
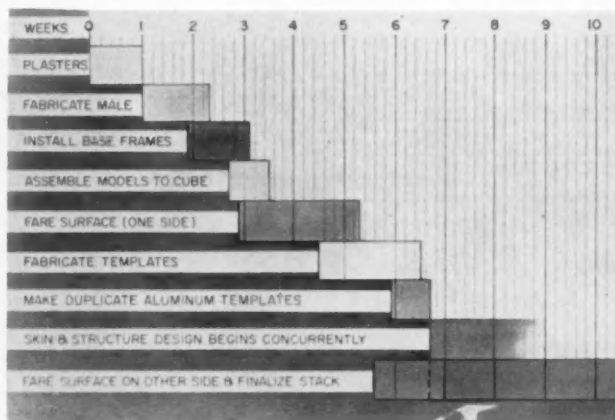
**See pages
52 & 53**

MASTER templates are now duplicated in aluminum by template duplicating equipment. Duplicates go to body engineering department where surface information is traced from templates on master body and front end drafts. As information establishing various views on draft is taken from 3-dimensional master model, problem of section conflict is mostly eliminated. Parallel with layout of surface information on master draft, work can begin on body structure and interior panel layout.

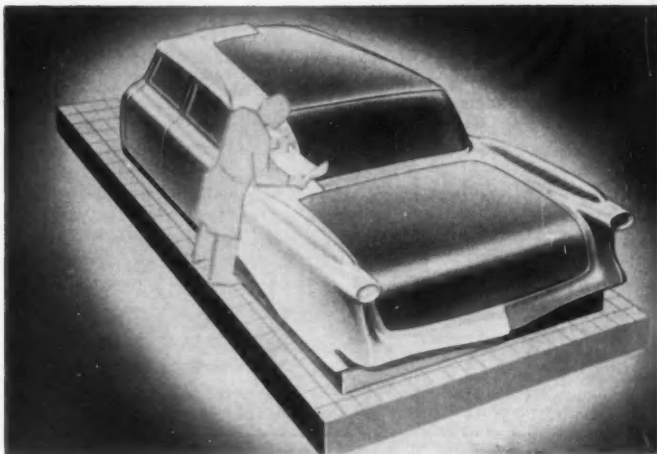


ORIGINAL templates are now used to complete the unfinished side of the model. By use of precision model bridge equipment, complete body stack can be made symmetrical, side by side, to the styling-approved surface.

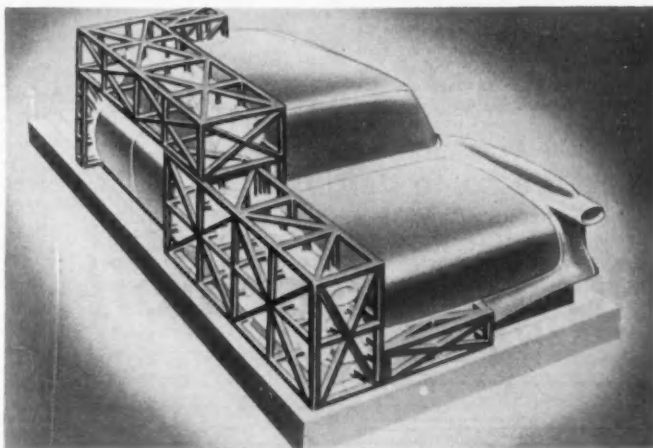
STACKED die model package is completed and approved in 10½ weeks, and individual die models can be shipped to tooling sources for start on draw lines. Plastic skin panels can be taken from model surface for use and evaluation for design aids or prototype construction and seating bucks. Cut line change can be incorporated into models quickly and economically. Appearance changes can be effected with local molds from revised clay model. Master model can now be removed from stack and shipped to die shop for keller requirements.



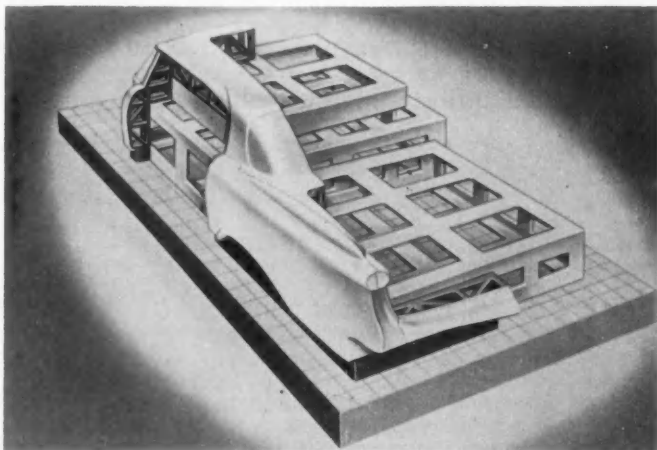
PLASTIC female molds can be taken from master die models by conventional technique. From these molds, die model duplications can be taken for both tooling and fixture requirements, and plastic hammerforms can be taken for prototype requirements as shown. Sheet metal panels can readily be fabricated, reflecting true production conditions since they are taken from the identical surface used for production dies. Windshield and backlight gages are taken from master model stack for tooling requirements.



MASTER fixture female can be fabricated off die model stack.



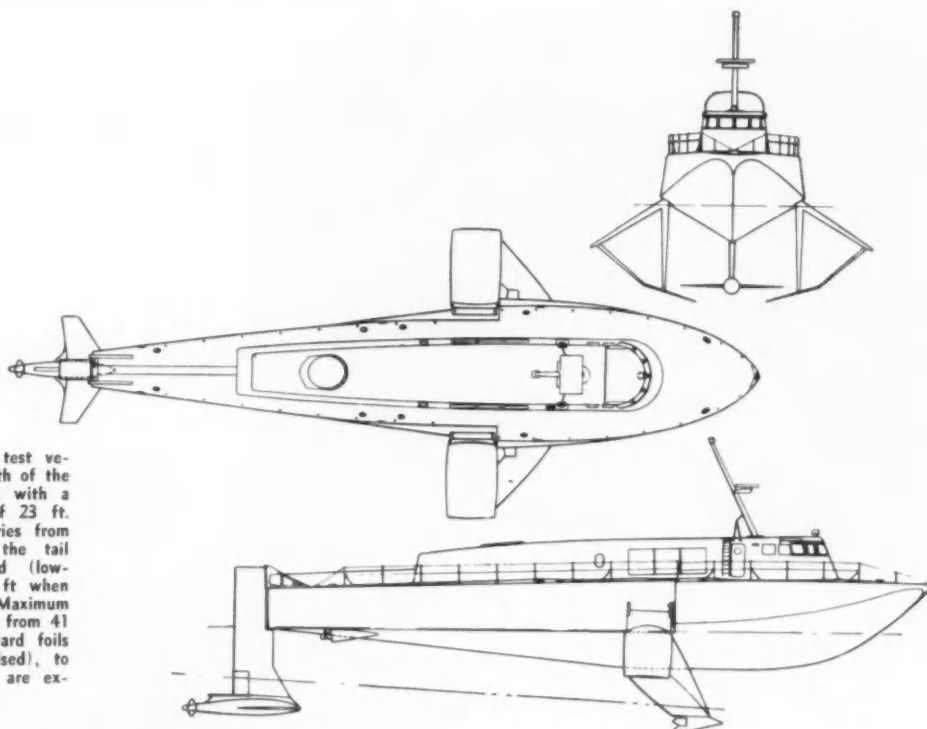
BASES are added and females are removed from master stack.



ONE-HALF master male fixture duplication fabricated from female molds. This male will serve as master fixture stack model after addition of brass plates to create outside of metal condition. The two halves are oriented on cube, brass is added, and fixture stack is complete, ready to gage all assembly fixtures for body in white.

To Order Paper No. 271A . . .
from which material for this article was drawn, see p. 6.

Fig. 1—Hydrofoil test vehicle. Overall length of the hull is 104.63 ft. with a maximum beam of 23 ft. Overall length varies from 117.56 ft with the tail assembly extended (lowered), to 128.73 ft when it is retracted. Maximum vehicle beam goes from 41 ft when the forward foils are retracted (raised), to 45 ft when they are extended.



Here are some details of a

90 ton hydrofoil craft . . .

soon to be tested.

This vehicle is being built for the U. S. Maritime Administration to demonstrate the feasibility of a large, ocean-going, hydrofoil craft. Such a vehicle is expected to fill the speed gap between conventional marine vehicles and aircraft.

Based on papers by

Glen J. Wennagel

Dynamic Developments, Inc., and

I. Palmer and J. K. Roper

Crumman Aircraft Engineering Corp.

A HYDROFOIL test vehicle capable of speeds up to 80 knots, having a maximum take-off weight of 90 tons, will undergo full scale testing this summer. Initially a subcavitating, surface piercing hydrofoil arrangement will be used to give speeds up to 60 knots. An alternate arrangement is envisaged, having fully submerged hydrofoils, to extend the speed range to 80 knots under cavity flow conditions. Vehicle range is 855 nautical miles at 60 knots,

with a 10 ton payload and a 90 ton initial displacement.

The basic geometry and dimensions of the vehicle are given in Fig. 1, which shows the two forward hydrofoils on either side of the hull, and one fully submerged tail hydrofoil.

Separate power sources are provided for foil borne and for displacement operation. In addition, two auxiliary power units are provided. Foil borne power is transmitted through the tail strut to a single pusher propeller of supercavitating design. For displacement operation, two water jet pumps on each side of the hull afterbody supply the thrust.

The hull is made of aluminum alloy, except for certain fittings. Frames and bulkheads are, in general, of welded construction, and skins are attached with riveted joints. High deadrise is in-

corporated in the hull design to minimize wave impact loads.

Among the different systems on this craft are included; a navigational system that may be operated automatically or manually; a below decks heating and ventilating system, engine room cooling and pilot house airconditioning; a salt water system for ballast, cooling, sanitary and deck hose services; a fresh water system; an electrical system supplied from two 60 KVA generators; and intercommunication, radio and warning systems. Fire detection and extinguishing are also provided for.

Hydrofoil design

Approximately 85% of the vehicle's 80 ton design gross weight is supported by the two forward hydrofoils. The remainder of the weight is taken up by the fully submerged tail hydrofoil, which is aided by the buoyancy of the propeller pod.

The cross sections of all the hydrofoil elements and the forward struts used for the 60 knot system have a subcavitating design. The hydrofoils act just like airplane wings except they operate in water. The differential pressure between the two surfaces gives the required upward lift. With the subcavitating design, as the foil is moved at faster speeds through the water, a point is reached where the upper surface pressure reduces to the water vapor pressure. This causes small bubbles to form which move on to the higher pressure region near the trailing edge, where they collapse. This phenomenon, called incipient cavitation, is accompanied by a loss in lift and causes erosion damage. The foils to be used in the envisioned 80 knot system will be fully submerged and will operate under cavity flow conditions, doing this to advantage. With this design the foil is kept at such a high angle of attack that the water is completely separated from the upper surface, resulting in a large stable vapor cavity which collapses far behind the foil. In this case there would be no erosion and speeds in excess of 100 knots could be achieved. The subcavitating design is limited to about 70 knots.

The difference between the surface piercing foil and the completely submerged foil is illustrated in Fig. 2. Each design is just a separate method for controlling lift. The surfacing piercing (area-controlled) arrangement achieves control by varying

the immersion of the lifting surface. The fully submerged design controls lift by varying the angle of attack as a function of load and speed.

For trim control in heave, pitch and roll, there are trailing edge flaps on the forward assemblies which extend on both sides of each vertical strut. Also, the tail hydrofoil is moveable in pitch. Transducers sense instantaneous craft motions and attitudes, and these signals ultimately control valves in the hydraulic system which actuates the flaps and foils.

Actuation of the forward and rear foil-strut assemblies, for extension and retraction, is done with hydraulic cylinders and mechanical linkages. There is a separate hydraulic system for foil borne and for displacement operation. Both use Skydrol 7000 as the hydraulic medium, and operate at a nominal pressure of 3000 psi. Solenoid actuated hydraulic valves control strut actuation. During extension, restrictor valves in the hydraulic systems prevent free-fall of the assemblies.

Each of the three assemblies has a separate actuating mechanism, but they are normally operated simultaneously. It is possible, though, to manually change the valving in order to separately retract either the forward two assemblies or the tail assembly, but the forward assemblies have no provision for individual retraction.

All struts are locked in both the up and down position. Locking of the rear strut in the down position is done with an hydraulic cylinder, using the piston rod as a locking pin. In the retracted position, an internal spring lock in its hydraulic cylinder serves to lock the strut. Automatic release of this lock occurs when pressure is applied to the cylinder in the direction of extending the strut.

The forward struts are locked in the down position by an hydraulically actuated latch mechanism. In the up position a mechanical interconnection of both assemblies provides the locking action.

Steering controls

There are, of course, provisions for steering in either mode of operation. For displacement operation, steering is accomplished by diverting the water jet exhaust through an angle of 41 deg from the keel. In addition to steering each water jet unit provides a forward, neutral, and reverse setting by

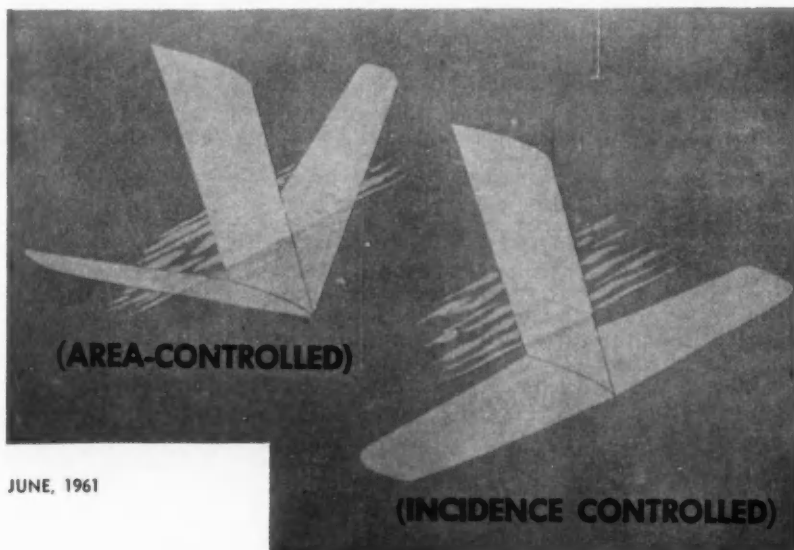


Fig. 2—Lift control. The surface-piercing design controls lift by varying the immersion of the lifting surface until the generated lift equals the total weight of the craft. The fully submerged arrangement controls lift through either incidence variation or flap position.

the relative position of a gate to the water stream. Aft of each gate is a rudder vane to provide steering thrust.

Directional control during foil borne operation is by a rudder in the lower region of the strut, consisting of two trailing edge flaps. These flaps, one on each side of the strut, extend outward individually about a vertical hinge line, to a maximum displacement of 27 deg.

Foil borne power

Power for foil borne operation is supplied by the MS-240 engine located above the main deck, in the aft end of the superstructure. The rating of this engine is 14,000 shaft hp on an 80 F day, with an SFC of 0.55 lb per hp-hr. Two basic sections comprise this unit; a gas generator and a free power turbine. The outer casings of these sections are joined to form a single unit, but the two components are connected only by an aerodynamic bond.

Air reaches the engine bellmouth through a tortuous path, first passing through water separators in the sides of the superstructure, above the weather deck. Air flowing through the main engine plenum also supplies the plenum of the displacement engine when it is in operation. Lubrication of the MS-240 is an integral part of the main engine package.

Starting of both the main and displacement engines is accomplished by air turbine starters located in the bullet nose of their respective gas generators. The starter air supply comes from the auxiliary power units.

Connecting the main engine to the propeller is a transmission which carries the power aft, above the weather deck, to a reduction gearbox, down the tail strut to a bevel gear box in the pod, then aft to the propeller. To accommodate retraction of the aft strut, an automatically actuated splined disconnect permits power to be disengaged from the strut section of the transmission. This feature also comes into play under emergency conditions, where the tail assembly might run aground.

To lubricate this transmission, a pump, driven off the reduction gearbox takes suction from a 525 gal oil tank and delivers the lubricant to the various components at a rate of about 180 gpm. Also included in the lubricating system are an oil cooler and a filter. To wet down the system prior to start, and to provide an adequate flow on shutdown, an auxiliary electric motor driven pump is also installed.

Scavenging is provided by several electrically, and also gear driven pumps, which return the oil to the main sump through a deaerating device. During prestart wet down the pod is scavenged by an hydraulically driven pump. Electric immersion heaters in the sump permit pre-heating of the oil before startup.

The propeller, which supplies the thrust for foil borne operation, is a three-bladed pusher type having a 36 in. diameter. At the design point, thrust is 25,000 lb, rotational speed is 2670 rpm and forward speed is 60 knots.

Displacement operation power

Displacement operation power is derived from the YT-58-2 engine located in the hull. This engine's rated power is 765 hp on an 80 F day, with an SFC of 0.71 lb per hp-hr. Its basic sections are; a gas generator, a free turbine and an integral reduction gear-

box. Power from this engine is split up with appropriate shafting and gearing, to drive the two water jet propulsion units on each side of the hull.

For lubrication, a combination pressure and scavenge pump, driven from an engine pad, takes suction from a 5 gal tank and discharges to engine bearings after passing through a filter. The scavenge pump discharges back to the deaerating storage tank through a fuel to oil cooler and a salt water to oil cooler. Another such pump, driven off the reduction gearbox, takes oil from the same storage tank to lubricate the reduction gearbox. Transmission lubrication is provided by a transmission geared pump taking oil from a separate 5 gal tank and discharging through an oil cooler. A filter is located in this system downstream of the cooler. An electric motor driven pump provides the scavenging.

Each of the water jet propulsion units driven by the engine consists of a three-stage axial flow pump having suction and discharge below the water line. The discharge nozzle has a diameter of 6.0 in. Each unit can absorb 350 hp to pump 7500 gpm. The thrust resulting from this action amounts to 2500 lb per unit.

Fuel system

The JP-5 fuel used with these engines is stored in four tanks, two on each side of the craft, having a combined maximum capacity of 9386 gal. To deliver the fuel where it is needed, three pumps are used; a booster pump for each engine and a transfer pump. Normally, suction for the fuel booster pumps is taken from the forward tank on the port side. The transfer system, which can transfer fuel from any tank to another, keeps fuel flowing into the suction tank in the following manner. Suction lines from each tank connect to the suction header of the transfer pump. Motor operated valves in each line determine, by their position, which tank is to be tapped. The delivery of the transfer pump is to the fill system where, again, motor operated valves determine the tank to be filled. The fuel transfer pump delivers at a rate of 40 gpm, which is better than twice the main engine's consumption at 60 knots.

The booster pump for the main engine has a rate of 30 gpm while the pump for the displacement engine delivers 5 gpm. Excess fuel from these pumps is recirculated back to the normal suction tank. In an emergency situation, the main engine booster pump can supply the displacement engine, the excess being recirculated to the normal suction tank. Similarly, for emergency foil borne operation, the transfer pump discharge can feed the main engine supply line through a special interconnection. Flow to either engine can be halted by strategically located valves.

Booster pumps for the two auxiliary power units also draw fuel from the normal suction tank. Either pump can supply fuel to either auxiliary power unit.

Fuel fill is from port and starboard fill connections manifolded to the transfer pumps discharge header. The fuel flows by gravity to the tanks through the motor operated discharge valves of the transfer system. The tanks on either side of the craft are united separately through manifold vents and a single gooseneck on either side of the weather deck.

To Order Papers Nos. 355C and S273 . . .

from which material for this article was drawn, see p. 6.

EXPLOSIVE FORMING

Has Many Advantages; one big disadvantage

Too much time needed to load and unload part from die. Kirksite, ductile iron, and concrete dies with epoxy faces among successfully used materials.

Titanium, molybdenum, and other refractory metals feasible at high temperatures.

Based on paper by **James P. Orr**, Ryan Aeronautical Co

EXPLOSIVE FORMING is gaining popularity as a means of fabricating metals. Evaluation of the process, however, reveals *both* advantages and disadvantages.

Advantages of explosive forming

Size—Parts to be explosively formed are not restricted in size. Dies of 50–60 ft diameter may be

constructed with the die right in the ground, either of concrete with an epoxy face or concrete with a steel face. The die, in this case, becomes its own tank of water (Figs. 1 and 2).

Pressure or Forming Force—Sufficient pressure and capacity for forming the strongest of the new superalloys is available through the medium of explosive forming. Pressures greater than those of the largest, most modern conventional machines

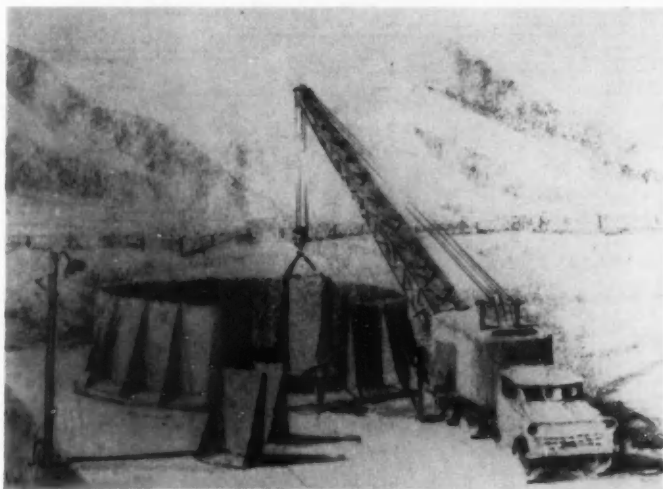


Fig. 2—Cross section of "earth base die" development.

Fig. 1—Large diameter "earth base die" illustrating the method of assembly of tank sections around the die cavity.

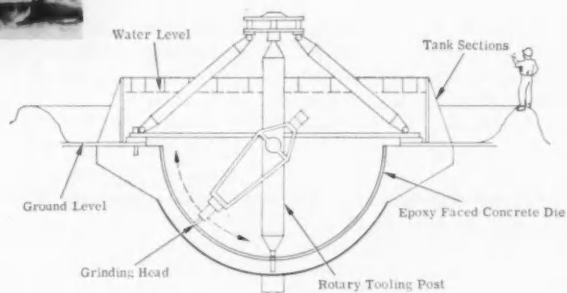




Fig. 3—Aluminum production part formed in five pieces and welded together as compared with one-piece explosively formed part.



Fig. 4—Titanium hemisphere formed at elevated temperature with explosive force utilizing alluvial sand as the shock transmitting medium.

Explosive forming at elevated temperatures

TITANIUM, molybdenum, and other refractory metals cannot be readily explosive-formed at ambient temperatures.

A technique was conceived whereby explosive forming could be handled at elevated temperatures. One of the first considerations was selection of a shock transmitting medium which would withstand high temperatures. Sand answered the requirements satisfactorily. Another consideration was the method of heating the die and the blank. This problem has been solved by using Calrods embedded in a ductile iron die and in a steel draw ring.

One of the first parts to be formed by this technique was a titanium helmet for the U.S. Army. Parts were deep drawn from a flat disc into the helmet shape by elevating the temperature of the blank to 1200 F. Thinning was held to a maximum of 0.007 in. Material thickness was 0.075 in.



Heated die configuration and titanium helmet shape.

are readily generated by explosives. Sufficient pressure is available to form even the most difficult parts.

Forming Speed—Conventional machines form metals at speeds up to 5 fps; explosive forming utilizes speeds up to hundreds of feet per second. Although still in the research stage, some tests have indicated that high rates of forming speed show advantages over slower forming speeds in increased elongation. In this connection, the type of explosives used should be considered, as explosives are manufactured which produce relatively low or high rates.

Cost Reduction—Explosive forming, as a manufacturing technique, will not replace conventional equipment. Generally, if the part can be formed satisfactorily, conventionally, it is more economical to do so. Of course there are exceptions to this: extremely large parts, parts with unusual contours, close tolerance parts, and parts requiring heavy pressures generally lend themselves to explosive forming. An example is a part that was made in five separate pieces (Fig. 3) and was subsequently redesigned to be explosively formed as a single piece. Explosive forming saved weight and cost.

Reduced Spring-Back—Parts have been consistently produced to within 0.001–0.002 in. of the die. This is possible because of the lack of spring-back encountered in explosive forming. Of the hundreds of dies produced for this technique by one company, not one has been machined to allow for spring-back. Spring-back has always been less than the tolerance allowed on the engineering drawing.

Work Hardening—Material formed by explosive means may be work hardened proportional to the severity of the form. Normal annealing methods may be employed, as with conventional forming. This may be carried on between explosive forming shots. It is generally not necessary to build stage dies in explosive forming work since the material may be moved by small explosive charges part way to the die, annealed, reinstalled in the die, and finish formed.

Work hardening has been used to advantage in obtaining high tensile strength in certain alloys which are not heat treatable. Alloys, as AM355 steel and 5086 aluminum, may be uniformly work hardened through the use of explosives. The application of uniform pressure and resulting uniform elongation results in the production of hemispheres and other shapes which have demonstrated uniform mechanical properties. AM335 steel, for example, has been successfully work hardened to 230,000 psi yield by explosive means.

Disadvantages of explosive forming

The great disadvantage to explosive forming, at present, is the amount of time consumed in loading and unloading the part from the die. The difficulty here is that a vacuum must be secured between the part and the die so as not to allow air compression in the die cavity. The necessity of drawing this vacuum has resulted in complicated die designs in

Tooling for explosive forming

THE following materials have been used and tested, and demonstrate certain abilities and limitations:

KIRKSITE can be used to produce inexpensive short-run jobs, particularly where the metal to be formed is of relatively light gage requiring low explosive pressures. Kirksite is not recommended for dies to be used for long-range production as it tends to grow in size and may eventually produce parts over blueprint tolerance.

DUCTILE IRON possesses the best characteristics for explosive forming dies found to date. The material has not compacted, causing dies to become oversize, with the explosive pressures used thus far. It shows good strength and ability to withstand explosive shock. It has not been excessively porous so as to create problems in securing a proper vacuum.

CONCRETE DIES WITH EPOXY FACES seem best able to meet the requirements for extremely large die sizes. The first step in the die-making process is to prepare a plaster master of the die cavity. This master is then coated with approximately one inch of epoxy resin. A metal cylindrical section is placed over the master; a suitable amount of retaining rod is placed within the section; and finally, a high strength, light weight concrete is poured into the section to form the die. After hardening, concrete and epoxy face are removed from the plaster and the die is complete.

which sealing problems slow down the handling procedure. Perhaps as new tooling techniques are established, this delay may be minimized.

Another disadvantage is the complex problem of explosively forming materials at elevated temperatures. This has been partly overcome through the use of alluvial sand as a shock transmitting medium instead of water. In this manner, electrically heated dies have been used to 1000 F temperatures. Titanium metals have been successfully formed with a minimum of spring-back and metal thinning by the use of this technique (Fig. 4).

To Order Paper No. 340A . . .

from which material for this article was drawn, see p. 6.

New pump shear tests studied as substitutes for cumbersome SAE 71R

Of four tests evaluated, two have current potentials
to replace the costly and time-consuming "SAE 71R Recommended Pump Shear Test."

Radiation has phenomenal potentials, but needs further evaluation . . .

Based on paper by

R. P. Nejak and E. R. Dzuna

Gulf Research and Development Co.

THE full power sonic and the ultrasonic shear tests have good current potentials for replacing the SAE 71R pump shear test for central hydraulic system fluids. This is indicated by an evaluation of four laboratory shear tests, in which eight experimental fluids were used by Gulf researchers.

The full power sonic shear test is a more strenuous version of the ASTM sonic shear test—for the latter turns out to be not severe or discriminating enough to match SAE 71R test data in reasonable periods of time.

Radiation—the fourth test procedure evaluated in the Gulf studies—definitely has potentials as a phenomenally rapid tool for shear testing . . . but needs further evaluation before becoming a proved technique.

The full power, the ultrasonic, and the radiation shear tests merit consideration—not only as possible replacements for SAE 71R—but also as possible accelerated techniques for evaluation shear characteristics of polymer-thickened fluids other than central hydraulic system fluids.

ASTM sonic shear test (tentative)

The ASTM sonic shear test (tentative) was evaluated in view of its widespread consideration as a standard shear study procedure. It requires the use of a Raytheon model DF-101 magnetostrictive oscillator rated at 200–250 w and 10 kc. The Raytheon oscillator assembly consists of a power supply unit and a treatment unit made up of a covered sample cup, the bottom of which is a vibrating diaphragm

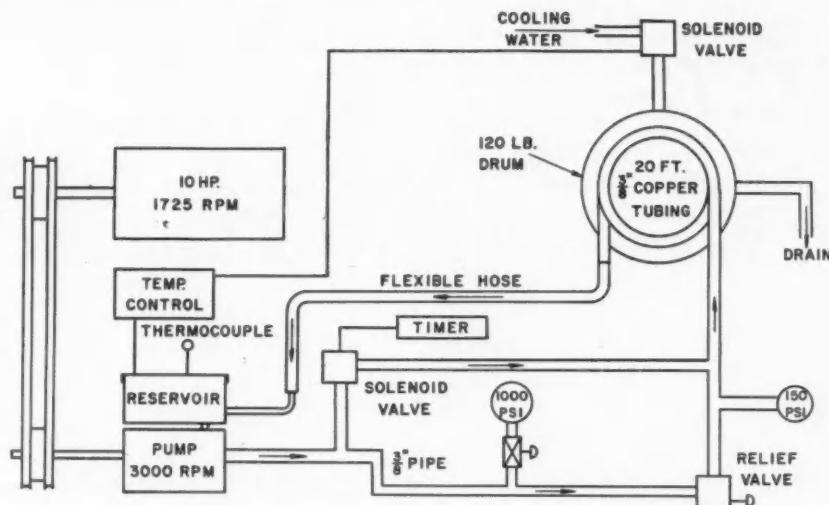
attached to a magnetostrictive laminated nickel rod. The rod and cup are surrounded by a field coil and encased in a stand that holds the rod, cup, and a built-in circulating system for water cooling. Operation involves tuning the apparatus to resonant frequency and running with power supply output currents and test sample volumes that allow the duplication of standard viscosity degradation—exposure time curves for ASTM reference fuels. Optimum power supply output current and test sample size values for ASTM sonic shear testing differ from laboratory to laboratory, due to variations in apparatus performance characteristics. The authors' studies were run with 25-ml samples at a constant power supply output current of 0.65 amp. The apparatus was cooled with 75 F water.

This test offers low cost per unit test, reduced testing time, reduced sample requirements, and it is now receiving widespread consideration as a standard shear test. On the other hand, there has been a singular lack of information relating ASTM sonic shear test data to recommended practices or to actual service data. Sonic shear test viscosity data at 210 F appear to be repeatable to ± 0.3 centistokes or better.

Full power sonic shear test

The full power sonic shear test is one of the tests devised as a possible approach for accelerating and improving the ASTM test. It is simply a variation of the ASTM test procedure, designed to gain maximum shearing capacity from ASTM recommended equipment. By this procedure, a Raytheon sonic oscillator unit is run at a power supply output current of 0.95–0.98 amp and otherwise normal ASTM sonic shear test conditions. A repeatability of better than ± 0.3 centistokes at 210 F is indicated for the

Fig. 1 — Central hydraulic system fluid pump shear test (SAE).



IN THIS ARTICLE, the authors evaluate the ASTM Tentative Sonic Shear Test and three other laboratory shear test techniques, as possibly more convenient, more rapid, and less expensive replacements for the SAE 71R pump shear test.

The SAE test, the authors say, probably simulates actual service requirements for central hydraulic system fluids quite well, since it calls for standard automotive mechanical equipment, used in a realistic cyclic test procedure. But, unfortunately, it has certain disadvantages, namely:

- 20 hr of operation is required for each test.
- A new, relatively expensive hydraulic

pump is needed for each test.

- Several hours is required to set up and calibrate instruments for each test.

The SAE pump shear test involves cycling 40 oz of test fluid continuously through an Eaton hydraulic pump at a discharge pressure cycle of 800 psi for 60 sec and 75 psi for 30 sec. Fig. 1 shows schematically the pump shear test. After 20 hr of cycling at a constant pump inlet temperature of 175 ± 5 F, viscosity measurements are taken at -40 F and 210 F. Samples with before and after shear viscosities not exceeding 2000 centistokes at -40 F and not less than 5.5 centistokes at 210 F qualify as central hydraulic system fluids from a shear standpoint.

full power sonic shear test procedure.

Ultrasonic shear test

The ultrasonic shear test was also devised as a possible substitute for the ASTM test. It is conducted with the following apparatus:

- Brush Mfg. Co. hypersonic generator model BU-240, rated at 250 w output power and a frequency range of 300-1000 kc.
- Brush hypersonic transducer (piezoelectric type) model BU-301-400, rated at 400 kc.

In the test 10 ml of oil is placed in a test tube fixed at the focal point of the transducer and exposed at resonant frequency with a generator power output of 130 w to the transducer and sample cooling at 75 F. Repeatability in this test is excellent — better than ± 0.2 centistokes at 210 F over a range of exposure periods of 5-60 min.

Radiation shear test

A radiation shear test procedure was developed and examined as a possible very-high-speed shear test replacement for the SAE Recommended Practice. It is based on the well-known tendency of ionizing radiation to degrade polymers in solution. It simply involves exposing 43-g samples of test fluid at room temperature to an electron beam from a 3 mev Van de Graaff accelerator controlled at 2 mev, 500 microamp, and an 8-in. beam scan. Exposures were run to approximate radiation dosage levels of 4, 8, and 15 megarads with simultaneous exact dosimetry according to a corrected sodium formate dosimetry technique. Under these conditions, it is possible to evaluate the shear characteristics of up to 100 samples of test fluid in an hour.

To Order Paper No. 294C . . .

from which material for this article was drawn, see p. 6.

FILLETS—

The Achilles Heel of Gear Design

Based on paper by

B. F. Bregi

National Broach & Machine Co.

FILLET DESIGN is often the weak link—the Achilles heel—of gear design. But this need not be so. Proper consideration of fillet position, shape, and processing plus gear finishing factors can lead to accurate, strong, reliable gears.

Improperly positioned fillets cause trouble

If the fillets in a gear fall too high on the gear profile, the mating gear can contact the fillet and cause excessive wear and noise. On gears with

relatively few teeth, fillet undercut can remove active contact between gears. This may weaken the tooth or cause excessive load and noise conditions. Too small a fillet can weaken the gear teeth.

In the gear production process, too high a fillet can result in finishing tool interference and breakage. The shape of the specified fillet can also influence the life of a generating-process cutting tool. A full radius form on the end of a hob, for example, gives maximum wear life. But, if various aspects of fillet generation with this tool aren't taken into consideration, the life of the finishing tool or the depth of the tooth can be affected.

Thus, a properly designed gear fillet must take into account the strength of the gear, the actual shape of the fillet produced by a specific tooth production process, the amount of involute profile needed for proper meshing with the mating gear, and adequate clearance for the finishing tool. If any of these considerations is overlooked, the Achilles heel effect of the fillet can come into play and cause excessive tool costs, poor gear quality, and possible gear failure.

Fillets important to gear finishing

The gear finishing process used to provide smooth, accurate involute profiles on production gears employs a helical gear-shaped tool having gashed teeth. This gear shaving cutter meshes with the work gear much like a mating gear. Thus fillet condition is an important factor in gear finishing. Fig. 1 shows a case where no fillet allowances have been made for the shaving cutter. The cutter tip contacts the fillet. This digging action causes excessive wear of the cutter teeth, affects the accuracy of the tooth profile, and may affect gear strength.

Thus some undercut should be provided to avoid shaving cutter contact with the fillet and promote maximum gear accuracy.

A gear with relatively few teeth (Fig. 2) has some natural undercut which may sufficiently clear the shaving cutter. Since natural undercut only occurs in special cases, other methods of providing fillet clearance are needed. The basic problem is to lower the fillet out of the path of the shaving cutter tip.

Protuberance-type tools can provide the needed shaving cutter tip clearance and simultaneously

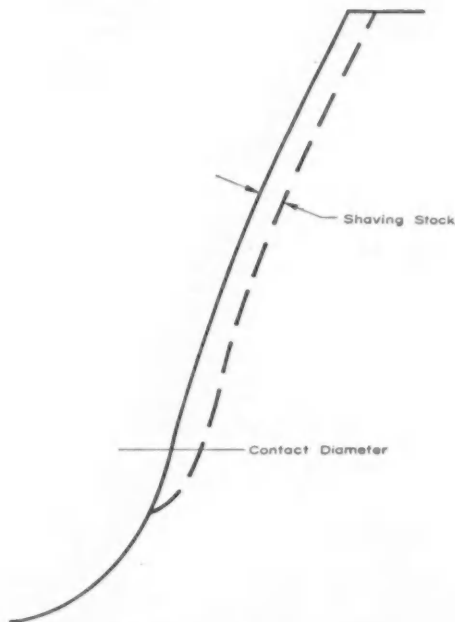
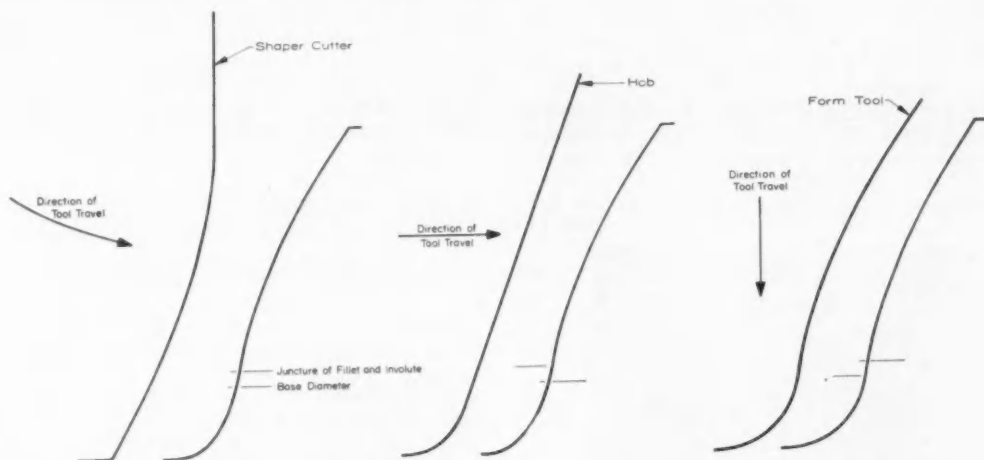


Fig. 1—Condition on gear tooth when no fillet allowance is made for the shaving cutter.

how FILLETS are produced



The same tooth produced by three different gear shaping methods, (l-r) shaping, hobbing, forming.

Three of the more popular methods of producing the same gear tooth are:

- The gear shaping process which makes use of a reciprocating tool in the form of a rack tooth or of a mating pinion.
- The hobbing process which employs a number of straight-sided rack teeth wrapped helically around a cylindrical body.
- The forming process which uses an in-fed form tool.

Gear shaping and gear hobbing are generating processes.

The fillet curve at the root corner of a generated tooth space is never of uniform radius.

It actually takes the form of a trochoidal curve generated by the tip corner area of the cutting tool. The point of tangency between this curve and the generated gear tooth profile is generally higher than that of the true radius produced by a form tool.

Fillets vary with the gear cutting process. Shaper cutters produce higher fillets than hobs for the same depth of cut and tip corner shape. As a result, standard shaper-cut gears are cut deeper than hobbed gears. When full-rounded fillets are used, additional whole depth of tooth is necessary. The shape of a fillet is correctly specified on gear drawings as that produced by a specified cutting tool with a specific tip radius or shape.

meet the basic requirements of correct fillet design. On a hob tooth (Fig. 3), the protuberance extends a small distance beyond the straight portion of the tooth that generates the involute profile of the gear. The amount of bulge shouldn't run 0.0005-0.001 in. more than the recommended shaving stock for each side of the gear tooth. This protuberance feature is also available on shaper cutters.

The gear fillet produced by a protuberance-type tool is shown in Fig. 4. Note that the undercut portion clears the shaving cutter tip and blends in smoothly with the involute portion of the tooth. Also, adequate involute portion is provided beyond

the point of contact with the mating gear.

Short-lead hobs, which generate at a lower pressure angle than conventional hobs, may improve the fillet condition in a gear tooth. These hobs roll on a diameter closer to the fillet area than the normal hob. This action often provides better control of fillet generation.

The use of protuberance-type tools prior to the shaving of all gears, regardless of the number of teeth, is a questionable practice. The position of the undercut when a fixed amount of protuberance is used will vary with the number of teeth on the gears being processed. Usually this undercut will

FILLETS

— continued

generate too high on gears with small numbers of teeth. This will destroy needed involute profile. The same tool used on gears with large numbers of teeth will provide an undercut too low to provide any useful purpose.

Theoretically, the protuberance-type tool should be designed for a specific gear, and in accordance with the number of teeth on the gear. On long and short addendum gears, the amount and position of protuberance must be carefully chosen so that final



Fig. 2 — A 12-tooth pinion having natural fillet undercut generated by a shaper cutter.

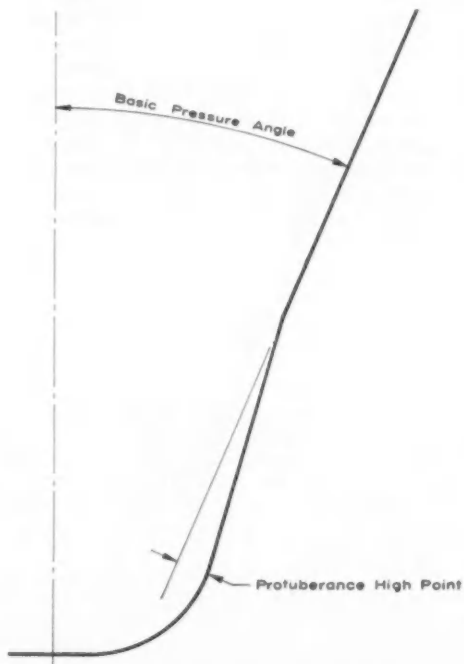


Fig. 3 — Typical protuberance-type hob tooth.

tooth design is not impaired by too much or too little undercut.

The position of the undercut should enable its upper margin to meet the involute profile surface at a point below its contact diameter. On small pinions, it is practically impossible to hold this point sufficiently low on the tooth. In such cases, the junction point will come slightly above the contact diameter. The undercut then should be of a shape to allow at least 0.0005 in. of stock at the mating gear contact diameter, which is removed in the shaving operation.

Surface finish in fillet area

At present, general practice is to have a shaving cutter or a grinding wheel finish only the involute profile of a gear. The fillet is produced by the generating tool. As fillets become a more critical design consideration, finish of the fillet will come under closer scrutiny by engineers desiring compact, highly stressed, long-life gearing.

The relative roughness of the fillet area that now exists after conventional gear shaving or gear tooth grinding processes presents a challenge to the manufacturers of gear production tools and equipment. Even though a fillet is properly positioned in accordance with the recommendations in this article, the fillet and root areas that remain after the finishing process are in a roughened surface condition that may prevent a heavily-stressed gear from providing maximum performance. The day is not far off when gear designers may specify smooth, precision tooth contours, including all of the root and fillet areas.

To Order Paper No. 333A . . .

from which material for this article was drawn, see p. 6.

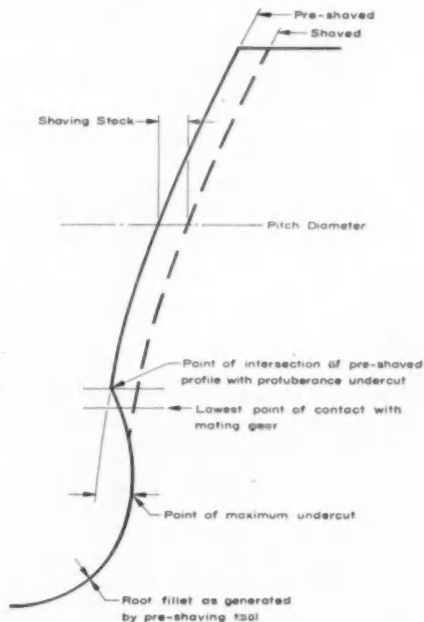


Fig. 4 — Typical gear fillet produced by a protuberance-type tool.

*A painless way for
your company to . . .*

START a Reliability Campaign

*—add a reliability group to your cost, performance,
and styling product requirement committees.*

Based on paper by **Hall Cary**
Battelle Memorial Institute

WITHIN each company, groups or committees are usually set up to consider product cost, performance, and styling.

Because reliability is a product requirement of equal importance, why not add a fourth group or committee? The reliability group could function in much the same manner as the other three.

Group functions

The product cost, performance, and styling groups function in several ways:

1. **They acquire data from many diverse sources.** For example, the group concerned with product cost would gather data on the cost of competitive items, spending habits of the American public, costs of parts used in the product, and production costs. The group concerned with product performance might keep records of the specifications of their own and competitors' products. In the case of automobiles, they might keep records of consumer driving habits, road hazards, and causes of accidents.
2. **They analyze the data.** The cost group, for example, keeps track of trends—cost-of-living increases, salary and wage structures, overhead, and competitive pricing trends. The group responsible for performance makes similar analyses of trends to set the best requirements for a saleable product.
3. **They perform a feedback function acting as a coordinate force.**

Because they gather pertinent data from many sources, these groups act as the eyes, ears, and the memory of the company. The groups inform management, engineering, production, and sales about the success of their product. More important, if the products are successful or not successful, they can tell why.

These functions are shown in Fig. 1.

The reliability group could function in the same way. The only difference would be the source and type of data collected, analyzed, stored and fed back. Fig. 2 shows the role of the four product requirement committees in the company. Much of the information used by these groups comes from management, engineering, production, and sales. This information is organized, analyzed, stored and referred back to the operating divisions of the corporation. Note that the statistical quality control group is set apart from the reliability group. Quality control gets its specifications from the engineering group and uses these to control production. Reliability engineering, as a committee activity, helps

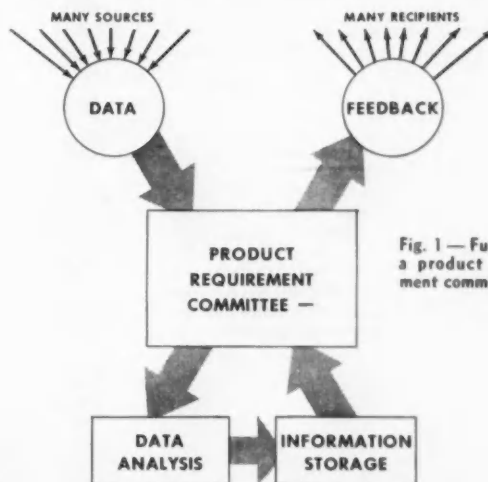


Fig. 1 — Functions of a product requirement committee.

Reliability Campaign

... continued

the engineering organization to establish these specifications.

Reliability, quality control, and production

The functions involved in the development and production of a product are shown in Fig. 3. The block labeled "management" includes a number of

activities: administration, sales, budget and finance, personnel, and corporate planning. The next block is "product planning board." In a firm manufacturing large systems such as missiles or automobiles, some executive group functions to set corporate goals, choose the products, and determine the priority of various products. They, in turn, charge some systems design group with the responsibility to develop one of the products. The systems design group determines the requirements for the major components of the system, giving these requirements to other design groups and to various vendors. From the systems design group stem parallel design and production programs. One program is concerned with the whole system and the other concerned with the components for that system.

Each program begins with an initial design, the development of a preliminary model or "mock-up" of the design, and tests on the mock-up. This set of activities, the design phase, is repeated. It can be visualized as a loop. The test information is fed back to the design group, the design is modified, the model is refined and further tested. When the design is proven satisfactory, it is released to the production engineering group.

The production engineering group translates the design into a form most amenable to production. This function also becomes a loop. The design is modified, fed into pilot production, and the prototype units produced subjected to test. To this point, both system and component development programs are functionally identical and can be shown the same way on the flow chart. But the components are used in the assembly of the system; so from this point on the two programs must be discussed separately.

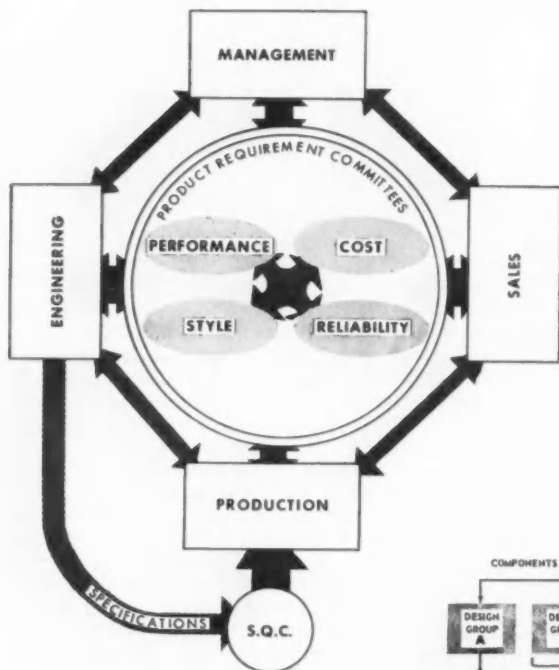


Fig. 2—Role of the four product requirement committees in the company.

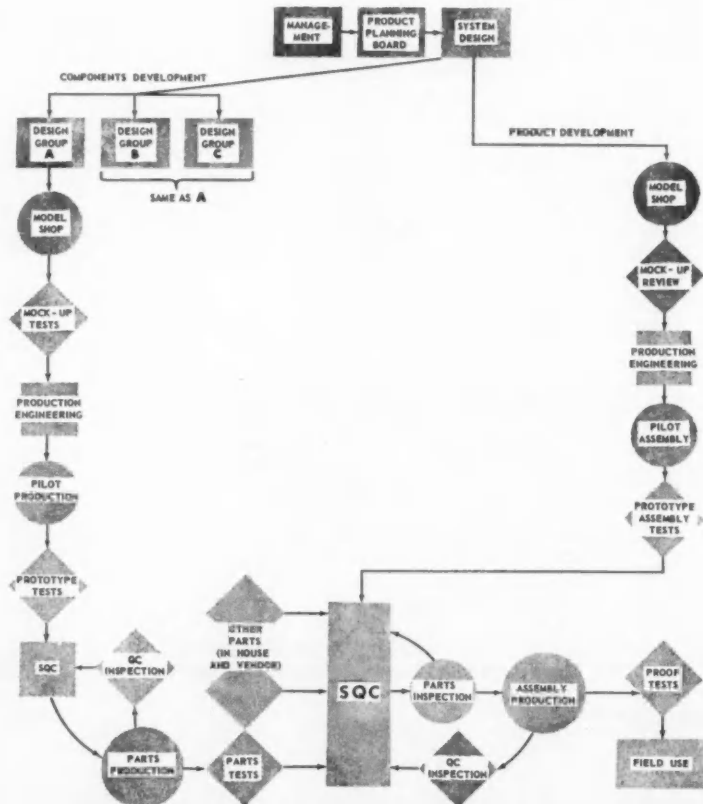


Fig. 3—Corporate activities involved in major product development program.

In the component development program, working drawings and specifications are released from production engineering to the quality control group. Quality control is responsible for holding component production to specified limits by judicious sampling and inspection. The components are then ready to be incorporated in the assembled product.

In the product development program, final working drawings and prototypes are also released to the quality control group. Again, the group must control the production of the assembly to the submitted standards. Furthermore, they must recheck all incoming parts for that assembly. Some of the assemblies coming off the production line are given proof tests to gain additional engineering information, and finally the product is distributed for use in the field.

Fig. 4 shows the product requirement committee superimposed on the diagram of Fig. 3. The arrows connecting the product requirement committee to various points in the flow diagram show the flow of data to the committees and the points of feedback and information exchange. Notice that the product requirement committees rely heavily upon information from various engineering tests: mock-up tests, mock-up review, prototype tests, parts tests, assembly proof tests, and perhaps most important of all, field usage. The feedback and information exchange is directed to management, the planning board, and the various engineering groups throughout the organization.

This article obviously proposes a scheme. Reliability engineering is hard to thrust into an organization without creating the general chaos usually caused by the invasion of a new engineering group. The proposed plan offers a painless yet effective way

MORE INFORMATION on the role reliability can play in your company has appeared in SAE Journal. See:

- 12-Point Program for Reliability
by C. V. Crockett, September 1960
- Reliability Program Upgrades Car Bodies
by W. E. Sehn, January 1961
- Mortality Curves Spot Reliability Problems
by A. J. Hofweber, February 1961
- Failure Rate Provides Desirable Measurement for Parts Reliability
by D. C. Beery, February 1961
- Buick Reliability Features Four Phases
by J. R. Gretzinger, February 1961
- Reliability Hinges on Management Disciplines
by L. S. Franklin, March 1961

to start a reliability campaign. Product requirement committees already exist in most major companies. If reliability is an important quality to be controlled, a reliability requirement committee should be added. Further, the major sources of reliability information already exist. To neglect this information is wasteful.

To Order Paper No. 326A . . . from which material for this article was drawn, see p. 6.

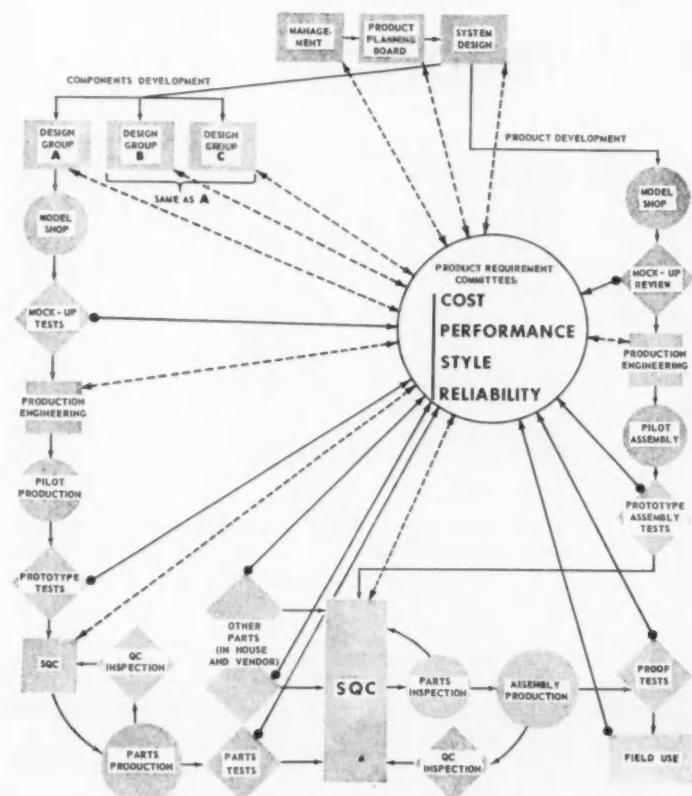


Fig. 4—Corporate role of product requirement committees. Solid lines represent primary data sources. Dotted lines represent feedback and information exchange.

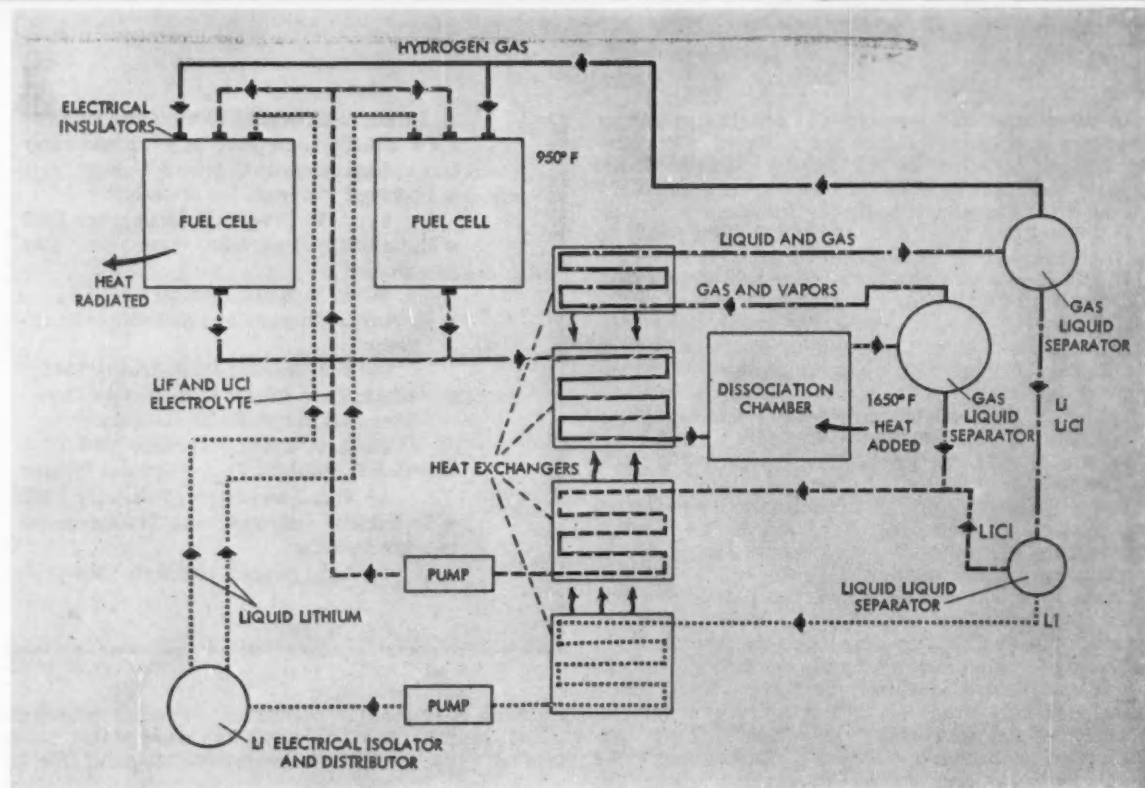


Fig. 1 — Proposed lithium hydrogen regenerative fuel cell. This particular unit is designed for zero gravity operation, and a power output of 500-w.

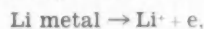
Lithium hydrogen fuel cell seen feasible

Based on paper by

Donald R. Snoke and John M. Fuscoe

Thompson Ramo Wooldridge, Inc.

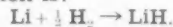
A LITHIUM-HYDROGEN regenerative fuel cell system shows promise as a power supply for both space and ground applications. In this closed cycle system the lithium (Li) and hydrogen (H_2) diffuse through the electrodes to react and form lithium hydride (LiH). The anode reaction is:



the cathode reaction is:



and the net reaction is:



The medium in which the reaction occurs is an electrolyte of fused lithium chloride (LiCl) and lithium fluoride (LiF) in eutectic proportion. The system is shown schematically in Fig. 1.

The closed cycle system has two other major functions besides producing the above reaction.

These functions are: 1. — Regeneration; 2. — Separation. The reaction products are continuously re-

moved from the fuel cell so that the reactants may be regenerated by thermal dissociation. Since the same reactants are always used, weight and volume are minimized because of the reduced amount of stored "fuel" required. The period of use is also extended by this process. After regeneration, the three components, Li, H_2 , and electrolyte are separated and returned to the fuel cell.

The components necessary for performing functions of the fuel cell are largely influenced by the specific application and the environment. A system developed to operate in a gravitationless environment for periods of 1 yr, with a 500-w, 28-v d-c output, will be discussed.

Fuel cell

The major features of the fuel cell which have to be determined are:

1. — The operating temperature;
2. — The electrolyte;
3. — The electrode design.

Operating pressure must also be fixed, but it is more a function of regenerator requirements.

Since the potential of the fuel cell decreases as

temperature increases, a minimum temperature fuel cell is desired. A reduced temperature also increases the cycle efficiency of this closed cycle system. On the other hand, since the fuel cell reaction is exothermic (18,500 Btu/lb of Li at the minimum temperature of the system) a higher temperature would facilitate radiative dissipation of this unwanted heat. Consideration of the trade-off between temperature and increased weight and volume due to radiator requirements will fix the optimum temperature. For this particular unit the optimum temperature was determined to be about 950 F.

The temperature chosen eliminates many electrolytes and suggests the use of fused salts. The electrolyte must be such that the fuel cell reaction product LiH is completely soluble; otherwise, solid LiH would form and produce fluid transfer difficulties. The electrolyte chosen has a melting point of 932 F.

Prime considerations in selecting the electrodes is the requirement for zero gravity operation, and the desire for a high current density, which allows the use of a minimum sized electrode. In this system the hydrogen electrode limits the current. When a porous electrode is used under zero gravity conditions, the hydrogen gas will remain attached to the electrode if its forced through. This reduces the fuel cell's power output. Insufficient H_2 pressure, however, will allow the electrolyte to enter the pores of the electrode, thereby "flooding" the electrode and decreasing the reaction. To avoid the additional weight and complexity of pressure regulation equipment, a metallic foil-type diaphragm is used, and the gas diffuses through it. A maximum current density of 70 amp/sq ft at 0.2 v has been obtained with this type electrode, and current densities up to 200 amp/sq ft are anticipated. A porous electrode is employed for the Li electrode since the zero gravity environment is not as critical there.

Regenerator

The regenerator for space application is designed to provide H_2 gas, LiCl and Li vapors, and a LiCl-poor electrolyte liquid. The two-phase fluid flow system is similar to a boiler designed for space applications. The design concept employed consists of a helical tube enclosed by the thermal source. A reduction in the fuel cell pressure to the regenerator pressure occurs in the regenerator, eliminating the need for a pressure reducer.

The chemical concentrations permissible, of the fuel cell reaction products, are important factors in the regenerator design. Determination of the required concentration comes from solubility studies of Li and LiH in the electrolyte, and fuel cell voltage-current density characteristics evaluated for various concentrations of LiH.

At the chosen concentration, approximately 98% dissociation is obtained at 1650 F and 20 mm Hg total pressure. A higher temperature would increase the theoretical cycle efficiency and also the hydrogen equilibrium pressure, however, the temperature is limited to 1650 F, to permit use of present-day construction materials for periods of months.

LiCl and Li vapors are also generated in the regenerator and contaminate the H_2 gas. To avoid electrode contamination it is necessary to purify the

H_2 by condensing out these vapors. A reduction of the regenerator pressure to 10 mm Hg absolute allows removal of all free Li obtained from the H_2 dissociation. Experimental fuel cells have been operated over the pressure ranges of 10 mm Hg for the H_2 supply pressure, and 1 atmosphere in the reaction chamber.

Separation

The separation system provides liquid Li, electrolyte, and H_2 to the fuel cells in three separate lines. The fluids it must deal with are in two phases, Li and LiCl vapors, H_2 gas, and LiCl-poor electrolyte liquid. The initial separation occurs at 1650 F and 10 mm Hg pressure. At that point, H_2 gas, Li, and LiCl vapors are separated from the LiCl-poor electrolyte. The vapors are then condensed out of the H_2 at 10 mm Hg pressure.

Separation of the H_2 takes place at a condensing temperature of 1300 F. This temperature provides negligible Li, and LiCl vapor pressure, and also an inconsequential amount of LiH formation. The H_2 gas, now removed from the condensed liquids, is returned to the fuel cells. The Li and LiCl enter a third separator where they are separated at 1300 F and 10 mm Hg pressure. The LiCl then joins the previously separated LiCl-poor electrolyte to form the eutectic mixture. Following this, the eutectic and the Li are pumped back to the fuel cells. In laboratory tests, separations of 90% or better have been achieved, and approximately 99% or better are expected with development.


Here again, gravitational effects call for design consideration. The present concept, utilizing pressure gradients to direct the flow of the gas or lighter liquid being separated, has demonstrated feasibility.

Auxiliary equipment

Two pumps are used in this system to boost the fluid pressure from 10 mm Hg at the separator to 760 mm Hg in the fuel cell. Because of the low electrical conductivity of electrolyte it must be pumped mechanically. A positive displacement double-bellows type is employed. The lithium pump can be electromagnetic positive displacement.

The use of a diffusion diaphragm eliminates the need for a hydrogen compressor. The near-zero concentration of H_2 on the electrolyte side of the electrode causes hydrogen flow through the diaphragm. Successful operation has been achieved using H_2 at 10 mm Hg absolute, and the electrolyte at one atmosphere. There remains a problem of screening many materials for high permeability of H_2 while being compatible with the lithium salts.

Three heat exchangers are used in this system, to conserve the energy of the fluids as they are cooled from the 1650 F temperature of the dissociation chamber, to the 950 F temperature of the fuel cells. One of these condenses the liquids from 1650 to 1300 F; another cools the Li from 1300 to 950 F, prior to being pumped into the fuel cell; and the third cools the electrolyte from 1650 to 950 F, before it is pumped to the fuel cell.

 To Order Paper No. 308D . . . from which material for this article was drawn, see p. 6.

Man is yardstick in GM's Interior Comfort Dimensioning System

Based on paper by

**Vincent D. Kaptur, Jr. and
Michael C. Myal**

General Motors Corp.

AN INTERIOR dimensioning system for passenger cars has been developed by General Motors which is based on the concept that the human being should be the yardstick for determining comfortable dimensions. It employs a two-dimensional manikin to give the package designer comfort information during the design stage and a three-dimensional manikin for verification of seating bucks and production vehicles.

THIS NEW GM interior dimensioning system differs from the traditionally-used, free 'A'-point system in using the hip joint center of the human body (the 'H' point) rather than the automobile seat as the reference point for dimensions.

The 'H' point, the bony protrusion of the thigh bone (trochanter) is unaffected by changes in torso posture or leg attitude.

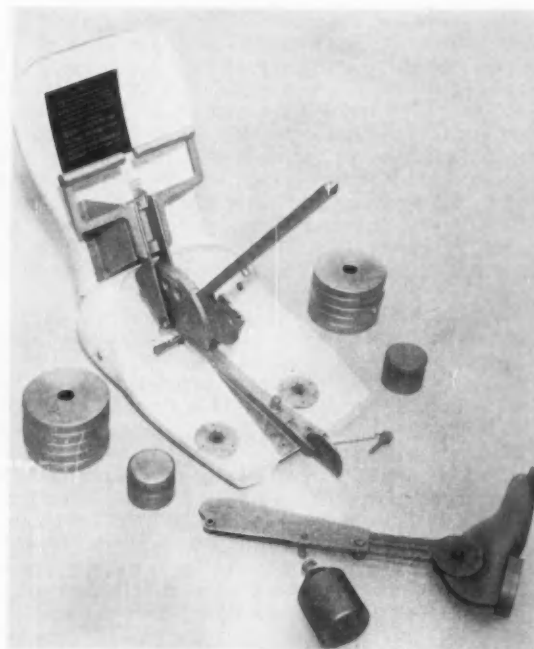


Fig. 1 — Three-dimensional manikin used by GM for interior comfort dimensioning. The 13 removable weights facilitate handling the tool.

In developing the human standard for the dimensioning system, no evidence was found to support the use of the average man in human engineering. If the measurements of a large body of drivers are taken to establish an average, no single person in the group will be found to be average. Therefore, the 90th percentile leg segment of the adult male is used as a leg roominess standard for package design. The degree of design seat depression is based on the 50th percentile adult male weight. This weight, which is 167 lb, determines the mean depression of the seats and is the equivalent of the 92.5 percentile female weight. Accordingly, 92.5% of females will sit higher than the 50 percentile male, which is an aid to women drivers since the average seated height of the female is over 2 in. less than that of the average male driver.

Design of manikin

The three-dimensional manikin tool is shown disassembled in Fig. 1 and fully assembled in Fig. 2. Data for making the tool were obtained from eight men meeting the 90 percentile height, 50 percentile weight standard. A depressed contour check was made of each individual and the contour established from the individual best fitting the average. Link dimensions of the 90 percentile adult male tibia and femur were obtained from Dempster's comprehensive work.¹ These dimensions coupled with the de-

¹ Dempster, W. T.: "Space Requirements of the Seated Operator," WADC Tech. Rep. 55-159, Aero Medical Library Contract No. AF 18 (600)-43, Dayton, July 1955.

pressed contour hip and knee joint locations determine the length of the 90 percentile leg segments. Army and civilian shoe schedules gave the shoe contour of the 90 percentile foot.

The manikin also has comfort angle scales designed for each body segment joint and for the back pan. Adjustability is provided for the tibia and femur links. A graduated sliding probe was designed to measure the amount of room in the passenger compartment for the torso and head of the occupant. Since the instantaneous rotation of the torso is about the hip joint, it was reasonable to design the measuring probe from the same point. Spirit levels were incorporated for orienting the device in space. Weighing of the device completed the design and construction.

The first trail runs for repeatability following definite installation procedure, showed the variation in hip joint height to be ± 0.05 in., a negligible difference, and ± 0.10 in. fore and aft. Subsequent controlled tests by the Proving Ground indicated the same result.

The two-dimensional manikin, used during the package design stages, (Fig. 2), is identical in dimensional respects to the three-dimensional tool. It is constructed from $\frac{1}{8}$ in. plexiglass and the tool contours are identical in shape to the fiberglass pans of the three-dimensional device. Degree quadrants provide the designer with comfort information.

How the manikin is used

There are nine steps in the use of the three-dimensional manikin to check seating location and attitude to see that they conform to what was established on paper. These are:

1. The unloaded device minus the lower leg segment, leg weight, and torso weights, is placed on the seat at the centerline of occupant, with the car or seating buck leveled to design specifications.

2. The lower leg and foot segment is attached and allowed to rotate freely and is rested on the toe-board, carpeted surface.

3. The lower leg segment weight (11.25 lb) is hung on the lower leg segment at its proper center of gravity.

4. The device is lifted by the torso weight hangers and moved rearward on the seat until a resistance of the seat back to the back pan is felt.

5. Without lifting the device, the back pan is again rotated slightly to re-check the seat back resistance. If none is felt, the preceding step is repeated.

6. The torso weight hangers are then loaded with the 10 torso weights, bringing the total weight of the device to 162 lb (5 lb deleted for steering wheel and armrest loading).

7. The loaded device is leveled laterally and the back pan is tilted forward until the torso weights are over the 'H' point. This releases any accumulated seat back friction.

8. The back pan is returned to its supported position.

9. The lateral level is checked and the device checked, if necessary.

Dimensioning procedure

After installation the device is prepared for dimensioning. The torso room probe is rotated to the full back position and the spirit level on the back angle quadrant is centered. The readings for back, hip, knee, and foot angles are then recorded and compared with the original design specifications. To measure torso room, the back angle quadrant is set at 8 deg and the torso room probe is rotated forward until the level is centered. The sliding probe is adjusted to the headlining and the scale is read to the nearest 0.10 of an inch. This measurement is then recorded and compared with the original design specification.

To Order Paper No. 267B . . .

from which material for this article was drawn, see p. 6.

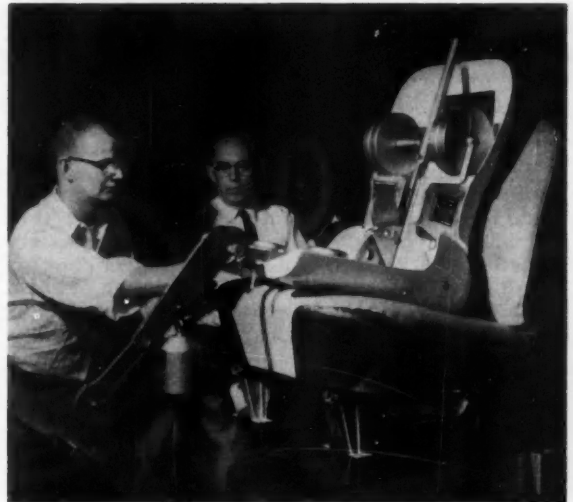


Fig. 2— Properly dressed, three-dimensional manikin being used to check seat depression and geometry under laboratory conditions.

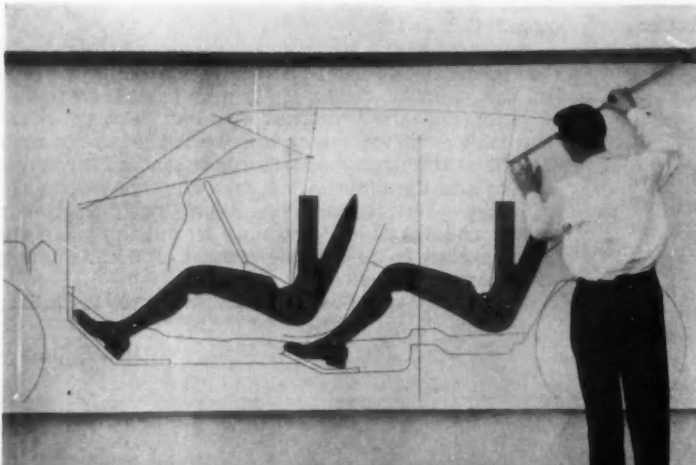


Fig. 3— Two-dimensional, plexiglass manikin used during package design stages. Here the technical stylist is using the completed package drawing to check backlight header clearance from the rear index eye.

SAE of Japan Sets Strength and Rigidity Requirements for Autos

Based on paper by

Mineo Yamamoto

Tokyo Agricultural & Technical University

THE Strength Research Committee of the SAE of Japan has developed strength and rigidity specifications for the automobile structure to meet the challenge of poor road surfaces in Japan.

Fig. 1 indicates the surface condition of a typical unpaved road in Japan. The height of bump or depth of dent of such a road, above or below the mean level, sometimes reaches 80 mm; at worst, they are 100 mm. Fig. 2 shows stress oscillograms obtained during the run of a small passenger car on a rough road, with bump and dent maximum of about 60 mm. The top oscillogram shows the bending stress variation at the rear portal frame near the rear shackle pin at a speed of 45 km per hr; the middle oscillogram shows the shear stress at approximately the same station; and the bottom oscillogram shows the bending stress variation in the front portal frame at the point of attachment of a cross member.

THE Japanese Ministry of Transportation, an agency of the Japanese Government, requested SAE of Japan to originate strength and rigidity specifications for the automobile structure.

SAE of Japan's recommendations were accepted by the Japanese Government and all Japanese auto manufacturers now must adhere to these specifications.

Fig. 3 shows the frequency distributions of maximum dynamic bending stresses in the upper control arm of the front suspension of another passenger car, when running over the rough road shown in Fig. 1 for 200 m at different speeds. Note that as the car speed increases, the frequency curve, which takes the shape of Gauss' normal distribution curve, becomes lower in height and wider in width resulting in a tendency toward increasing maximum stress and decreasing frequency at lower stresses.

Frequency distribution of acceleration and stress of an unsprung part, or sometimes of a sprung part immediately above the axles, takes the form of Poisson's distribution to the first approximation. This condition may be attributed to the resonant vibration of the unsprung mass picking up the corresponding pitch of surface roughness for the relevant speed. Such characteristics are typical of the vehicle with a suspension of relatively high stiffness. Fig. 4 shows the frequency distribution curve of vertical acceleration of the sprung part directly above the front wheel of a motor tricycle truck.

SAE of Japan recommends calculation of the time fatigue strength of the structural components by using the frequency distribution curve of acceleration or stress which may be either anticipated or obtained in the actual run of the vehicle. The minimum fatigue safety factor adopted in the recommendation is 1.3.

For most of the structural members of the vehicle, the mean stress is constant and the dynamic stress in the member varies according to the frequency distribution curve for that member. For this case, the fatigue safety factor may be taken as the ratio of actual time fatigue strength or load of the member to the dynamic stress or load imposed on the member. But in some members, both the mean stress and variable stress may be multiplied in the same ratio. In both these cases, the linear damage law may be applied.

Usually, it is difficult to estimate the frequency



Fig. 1 — Typical surface condition of rough road in Japan.

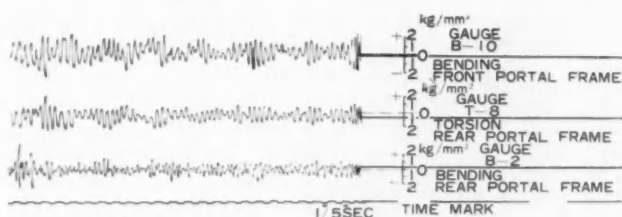


Fig. 2 — Stress variation on rough road.

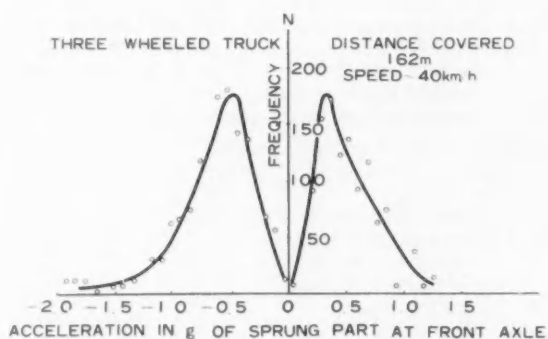


Fig. 4 — Typical frequency distribution curve of acceleration for parts near the axle in a vehicle with suspension springs of high stiffness.

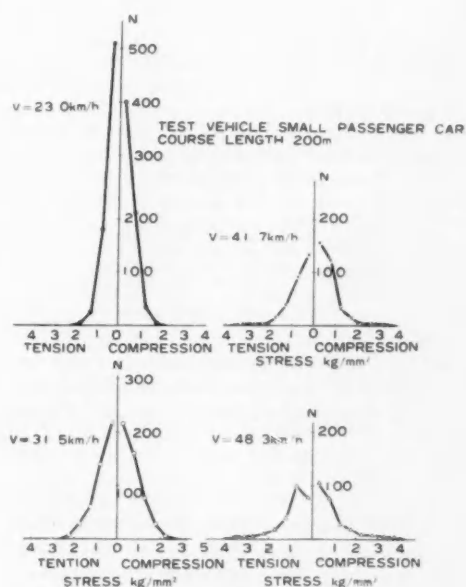


Fig. 3 — Frequency distribution of dynamic bending stress in upper control arm.

Fig. 5 — Simplified method of finding fatigue safety factor.

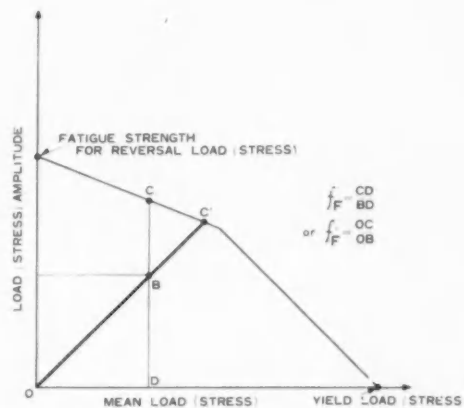
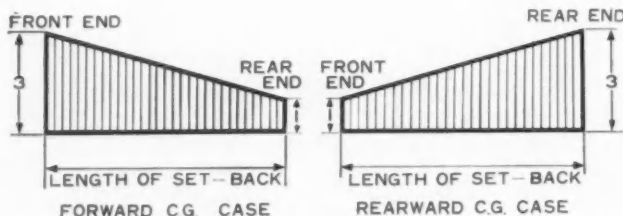


Fig. 6 — Distribution of load on rear body of truck.

SAE of Japan Sets Strength and Rigidity Requirements for Autos

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distribution curve of stress, acceleration, or load in the prototype stage of a vehicle or at the beginning of development. For such a case, the recommendations propose to calculate the fatigue strength of the structural member by using the single effective dynamic stress level. Fig. 5 shows the two methods of calculation of fatigue safety factor proposed in the recommendations. Where the mean stress is constant, and only the stress amplitude varies, f_F is the fatigue safety factor. Where both the mean stress and dynamic stress vary, the fatigue safety factor is given by f'_F . The designer may choose either of these methods taking into consideration the nature of the load. Also, he must take into account the intended life length of the vehicle, anticipated road conditions to be covered, the percentage of the rough road length to be covered in the lifetime of the vehicle, and the speed of the vehicle on the rough road.

In addition to the fatigue safety factor, the recommendations request that all structural members have the following safety factors for static loads:

1. Required rupture safety factor — 1.6
2. Required yield safety factor — 1.3

Moreover, for parts that are liable to deteriorate during the lifetime of the vehicle or whose strength is uncertain owing to incomplete inspection or some other reason, the specs request the use of special

factors. The safety factors requested in these cases are the required safety factors cited above, multiplied by the recommended special factors. In the recommendations, the casting factor, bearing factor, deterioration factor, and cable factor are included.

The recommendations also request calculating the strength of the vehicle for the various load distributions for trucks and buses. The proposed load conditions are:

1. No load on the setback.
2. Nominal loading.
3. Overloading for the bus.
4. Forward c.g. loading.
5. Rearward c.g. loading.
6. High c.g. loading.
7. Low c.g. loading.

For cases 4 and 5 above, when there is no concrete data for the load distribution, the load distribution in the setback shown in Fig. 6 is recommended. In these cases, the uniformly varying distributed load, in which the load strength at the ends is in the ratio 3:1, is recommended. The specs also define nine representative loading cases, for which the entire vehicle should be safe in strength. These are:

1. Symmetrical vertical loads.
2. Asymmetrical vertical loads.
3. Side loads.
4. Symmetrical fore-and-aft loads.
5. Propelling system loads.
6. Asymmetrical horizontal loads.
7. Steering system loads.
8. Operating loads.
9. Special loads.

To Order Paper No. 298B . . . from which material for this article was drawn, see p. 6.

Crusade on Compressor problems

Attempts to develop new compressor units and achieve higher pressure ratios have focused design attention on the plaguing problems of surge, transonic flow difficulties, and proper matching of components. Recent work dealing with these long-standing compressor difficulties is discussed in this article.

THE overall performance characteristics of a typical compressor are composed of the characteristics of the individual components. Consequently, undue design emphasis on a particular component may well result in poor performance.

The main parts of the compressor are: the inducer, the rotor, and the diffuser. The air entering the compressor has angular momentum imparted to it by the inducer before passing on to the rotor. In the rotor the air is centrifuged, its angular momentum increasing to a maximum at the rotor tip. The air then passes into the diffuser where the velocity head is converted to pressure.

The efficiency of the inducer is quite important as considerable turning is achieved there. The degree of turning efficiency depends upon specific choice of blading geometry. To achieve more efficient turning several techniques are available. Two rows of airfoil blading in cascade can be used to accomplish the required turning, instead of a channel inducer. Also, stationary inlet guide vanes to impart whirl may be used to unload the inducer. However, their use reduces the pressure ratio for a given impeller tip speed and overall compressor efficiency.

The rotor design is largely dependent upon the pressure ratio desired. The blades may be backward curved or straight radial, the latter being mandatory for stress reasons at pressure ratios above 3.0/1. To achieve high pressure ratios and yet maintain acceptable tip speeds, intermediate splitter blades may be used. The larger number of blades increases the slip factor and the pressure ratio for a given tip speed, if rotor efficiency is maintained. Thus flow distortions can be controlled while inlet solidity requirements are maintained.

Rotor losses include scrubbing, recirculation, and the previously mentioned slippage. Scrubbing results from frictional resistance and secondary flows between the stationary outer shroud and the rotating impeller. In some cases the shroud is an integral part of the impeller so the need for close axial alignment with a stationary surface is avoided. Recirculation loss stems from additional work done on air which is forced back into the impeller. This occurs when the air does not have sufficient energy to withstand the pressure gradient in the diffuser. Slippage is the deviation of the air from the blade angle, resulting from channel circulation and boundary layer growth. It determines the extent to which full rotor tangential velocity is imparted to the air.

The efficiency of the impeller can be substantially

increased by applying aerodynamic criteria to the design. The fundamental problem involved is control of the boundary layer. The boundary layer is the region of retarded flow near the wall of the passage, caused by fluid viscosity. If the energy here is too low, the flow cannot progress into higher pressure regions and separation of the boundary layer occurs. An unstable condition results, and an eddying region is formed, of no net flow in the direction of main motion. This formation of eddies constitutes a loss. In addition, the effective flow area is reduced, causing higher velocities in the main flow. Furthermore, a large region of separated

THE MATERIAL upon which this article is based comes from the following papers:

Role of the Compressor in Limiting Automotive Gas Turbine Acceleration by **C. A. AMANN** and **G. E. NORDENSON**, GMC, Paper No. 268F

Transonic Flow Problems in Centrifugal Compressors by **ALFRED F. STAHLER**, Boeing Airplane Co., Paper No. 268C

Influence of Impeller and Diffuser Characteristics and Matching on Radial Compressor Performance, by **COLIN RODGERS**, Solar Aircraft Co., Paper No. 268B

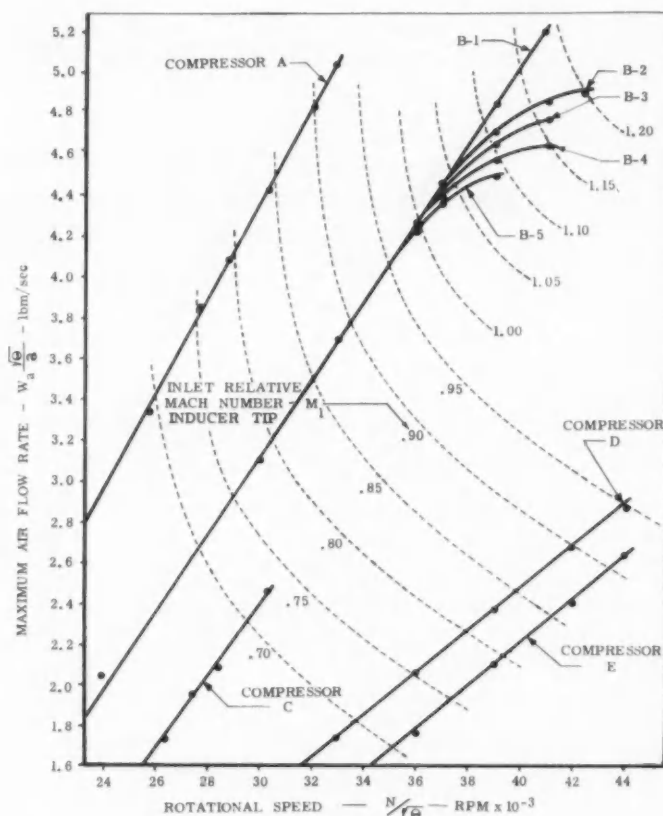
Development of the Chrysler Automotive Centrifugal Compressor by **G. A. BALL**, **A. H. BELL**, and **L. B. MANN**, Chrysler Corp., Paper No. 268E

Aerodynamic Design and Performance of Centrifugal and Mixed-Flow Compressors, by **F. DALLENBACH**, AiResearch Mfg. Co. of Arizona, Paper No. 268A

To order any of these papers, turn to p. 6.

Fig. 1 — MACH NUMBER EFFECT ON AIR FLOW RATE.

Certain compressors are susceptible to a declining air flow rate as the inlet relative Mach number enters the transonic region. This effect is more severe where the t/c ratio and leading edge radii of the inducer are larger.



Compressor problems

... continued

flow entering the diffuser makes it difficult to obtain satisfactory pressure recovery.

Whether and where the boundary layer will separate and how this can be avoided or postponed depends on the pressure and velocity distribution outside the layer.

Generally, separation will occur for the velocity ratios (outlet velocity/inlet velocity) commonly used. But the boundary layer thickness will be lower if the flow is decelerated rapidly, prior to separation (in the inducer region). It is also desirable to load the blades lightly near the outlet. Compensation for this, in order to impart the desired momentum to the flow, is achieved through a higher inducer loading.

In the diffuser a critical problem is encountered. The high velocity air from the impeller tip must be diffused to the low velocities normally required at the compressor outlet. Two types of diffusers may be used, vane and vaneless. Vaneless, free vortex diffusion has several distinct advantages:

- (a) The sonic transition is apparently accomplished without shock.
- (b) Impeller blade wakes are given time to decay.

(c) Axial distribution of velocity should become more uniform.

It is particularly applicable in the pressure ratio range below 2.5:1. Here the efficiency is comparable with vane diffusers and flow range is wider. (Flow range is extremely desirable when more than one stage of compression is required since stage matching becomes less acute.)

For higher pressure ratios diffusion is most efficiently accomplished with vane diffusers preceded by an intermediate vaneless space. Vanes exert greater flow control and their presence may be exploited to obtain increased rate of static pressure by deflecting the flow outwardly. The vaneless diffusion has a smoothing effect on the disturbed flow emitted from the impeller tip. This has a favorable influence on vane diffuser operation, but the vaneless region is extremely sensitive to surface finish.

The transition between the vaneless diffuser and the channel diffuser has the function of providing a uniform velocity at the throat of the channel.

Profile selection of the vane diffuser is a compromise between the incident Mach number, the vane number required to avoid impeller excitation in the operating speed range, and the diffuser entry to exit ratio.

Some specific problems encountered in centrifugal compressors are now discussed.

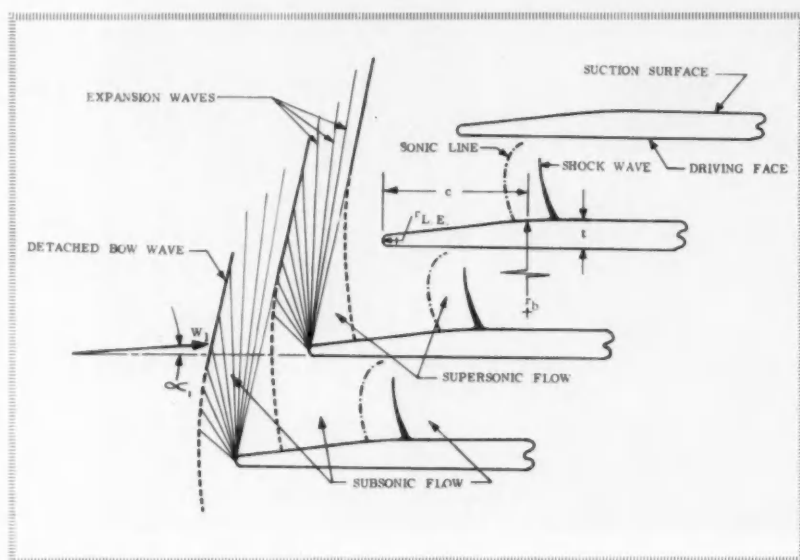


Fig. 2—**THE DECLINING AIR FLOW RATE** is ascribed to the fact that sonic velocities are reached in the inducer, as indicated by the sonic line. Flow past this line is affected only by the stagnation properties of the incoming air and not the downstream pressure. The ensuing shock is a source of compressor loss.

Transonic flow problems; cause and cure

"Mach number trouble" with centrifugal compressors will adversely affect overall efficiency, air flow rate, and flow range. Mach 1 flow, if present, occurs at the impeller inlet and outlet. The resulting shock waves and flow restrictions account for the drop in performance.

Flow blockage

Most compressors exhibit a linear relationship between rotational speed and air flow rate. However, at higher inlet Mach numbers some compressors deviate from this in that the increase in flow rate is less than expected. This effect is evident in Fig. 1 where several experimental and production compressors are compared. The reason why the non-linearity develops is that sonic flow exists at the inducer entrance. Once sonic velocity is reached at a point, downstream pressure cannot affect flow past that point. Instead the stagnation properties of the incoming air fix the flow.

Sonic flow occurs somewhere along the blade when a unique critical approach velocity is reached. With reference to Fig. 2, sonic velocity is first reached on the suction surface of the rapidly moving blade tip as flow turns about r_L . The locus of velocities that have reached Mach 1 is represented by the sonic line. The length of this line depends on the extent which the approach velocity exceeds the critical value for the particular blade shape. In turn, the extent to which flow is blocked depends on the length of the sonic line.

A study of the blading used in the different compressors analyzed indicates the direction to go for minimizing the inlet blockage effect. It is found that larger t/c ratios and leading edge radii result in greater deviations from the linear flow-speed relationship. Reduction of these quantities are limited, however, by the strength requirements for resisting vibration fatigue failure. Another approach to the problem is to increase clearance at

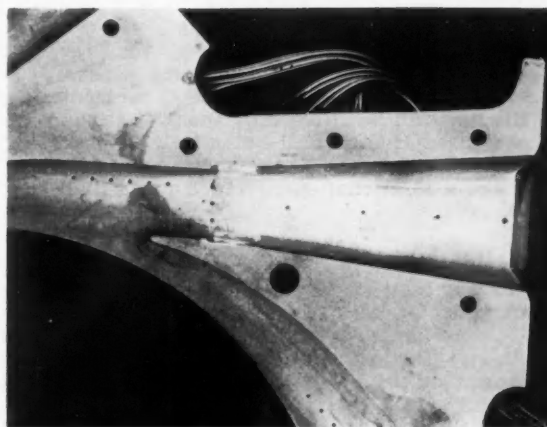


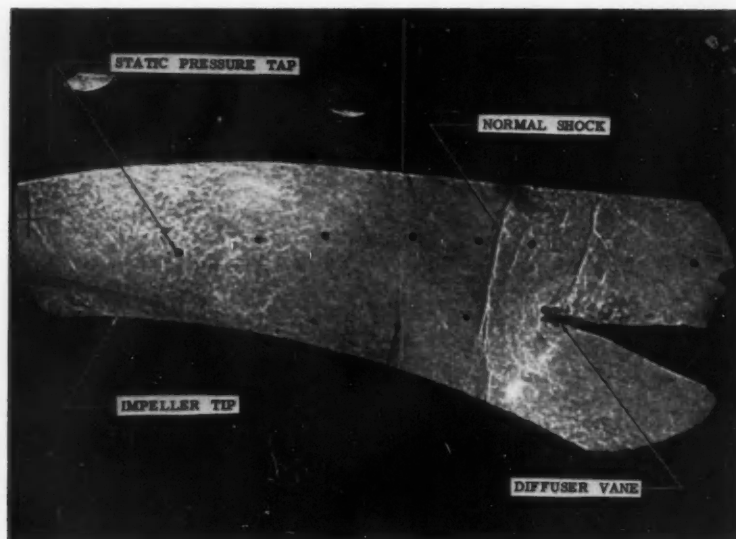
Fig. 4—**BOUNDARY LAYER TRIPS IN THE DIFFUSER THROAT.** These trips restrict boundary layer separation to points downstream of the diffuser throat. This maintains the effective throat area invariant with time.

the inducer blade tip. Blade rigidity will then be preserved but compressor efficiency drops off.

Efficiency drop

High Mach numbers at the inducer inlet also tend to cause a drop-off of the over-all compressor adiabatic efficiency. This effect is related to the normal shock which occurs along the flow passage, as shown in Fig. 2. This shock is the means by which the flow, which has expanded to supersonic velocities while turning about r_L , is decelerated. The shock loss is mild if only limited regions of slight supersonic flow are involved. But, if the maximum surface Mach number in the region between the sonic line and the shock wave exceeds certain limiting values (depending on the Reynolds number and the boundary layer) pronounced separation accompanies

Fig. 3—SHADOWGRAPH PICTURE OF FLOW AT DIFFUSER ENTRANCE—MAXIMUM AIR FLOW RATE. The shock at the diffuser vane tip is similar to that in the inducer and similarly produces losses. Less is known of the shock upstream of the vane. This shock produces periodic flow variations which can cause inducer blade failure.



Compressor problems

... continued

the shock and large efficiency losses occur.

As is the case with the sonic line, a larger portion of the flow will be affected by shock losses as rotational speed is increased. Similarly, the problem may be solved as above or by choosing an inlet diameter and a rotational speed which avoid high inlet Mach numbers.

Discharge losses

Avoiding high Mach numbers at the impeller discharge, also an area of transonic flow problems, is another matter. The desire for high pressure ratios eliminates this possibility. Instead, other means of improving the flow conditions in this area must be found.

Sonic flow at the discharge causes conditions at the entrance to the vaned diffuser which are similar to those at the inducer inlet. The situation existing at the maximum air flow rate or choked diffuser throat condition, is shown in Fig. 3. This is a shadowgraph taken at the diffuser entrance and it shows a small shock wave in the diffuser channel. This shock is the result of flow deflection about the vane tip, similar to the deflection about r_i at the inducer inlet. A shock also exists upstream of the diffuser vane tip.

When the flow is reduced close to the minimum or pulsation condition the shock at the vane tip is found to oscillate. There also exists a separation region of transient nature in the boundary layer of the diffuser walls. This is probably connected with the oscillatory behavior of the shock wave. The rate of occurrence and relative size of these transient separations are most severe as the surge or pulsation point of the compressor is approached.

Two modifications of the diffuser can stabilize the inlet flow pattern. One change involves drilling small holes through the leading edge of the diffuser vane. This allows some of the boundary layer to

flow from one side of the vane to the other. This allows stable operation to be extended to lower flow rates with only a slight efficiency drop.

The other alteration is the cutting of two small steps or boundary layer trips in the diffuser channel wall, at the throat area. These steps, shown in Fig. 4, create a fixed separation point downstream of the throat. The tendency of the separation point to move upstream is thus restricted and the effective throat area will remain invariant with time. As a result, the flow range of the compressor throughout the entire operating region is increased. Only a negligible change in overall efficiency was encountered here.

The shock in the vaneless region of the diffuser, shown in Fig. 3, is seen to extend into the moving impeller tip. The shock pattern formed by the shock at each diffuser vane subjects the impeller channel to pressure and flow variations. This flow pattern subjects the inducer blading to periodic variations in loading. The frequency of this loading increases linearly with rotational speed and may result in blade failure if the natural frequency of the blading is reached. In addition, compressor efficiency at the higher pressure ratios is limited by this shock. Investigations are being made to better determine the nature of this shock and the means to reduce or eliminate this loss.

The surge problem

Lagging acceleration of the gas turbine is a real, if overemphasized trait. To a large extent, compressor surge is responsible for this characteristic and must therefore be avoided. The prime control of engine acceleration is turbine inlet temperature, a function of fuel flow. Evidently, the extent of temperature elevation is restricted by material limitations. But compressor surge may occur even before this point is reached and thus becomes the factor which determines the acceleration lag.

Some steps to minimize acceleration lag can be taken in the drawing board stage. Reducing the polar moment of inertia and rotational speed of the

gasifier helps but these routes generally conflict. Lower operating speeds demand increased rotor diameter to maintain a reasonable peripheral velocity, and thus adversely affects moment of inertia. Besides, there are structural and aerodynamic limitations involved in reducing moment of inertia. Increasing the idle speed is also a beneficial practice as it reduces the speed range through which acceleration is required.

Characterized always by fluctuating flow, usually by an audible report, and sometimes by its induction of mechanical failure, surge has come to be respected and avoided. All aerodynamic compressors suitable for use with turbines are subject to this flow instability. It is brought on by excessive exit restrictions. The reduced mass flow rate caused by the increased gas temperature of the accelerating turbine is as effective a restriction as a closing discharge valve.

Increasing the surge limit

In developing the GT-305 automotive gas turbine there was a head-on encounter with the problem of surge. The performance map of Fig. 5 illustrates the situation. At any speed there is a flow rate below which surge will occur. This is indicated by the surge limit. Steady state operation takes place at conditions represented by the equilibrium line. When the engine accelerates it operates between these two curves. Unless an adequate surge margin is maintained between the acceleration curve and the surge limit, the limit will be exceeded during acceleration.

Urged on by the goal of reaching design performance, the GT-305 engine equilibrium line was moved toward the more efficient region in the neighborhood of the surge limit. At the same time the allowable fuel flow was increased for faster accelerations. Ultimately surge occurred during full throttle acceleration from idle speed. The attempted increase in acceleration performance at a time when surge margin was being reduced triggered the surge.

Investigation of the problem with the aid of a strip chart recorder showed the pressure variations at the inlet duct and the vaneless diffuser space. A number of interesting facts were revealed in the operation problem area of the compressor. Upon reducing flow rates at high speeds, an audible deep surge was encountered without prior warning from the pressure signals. At a lower speed, deep surge was preceded by a zone of mild but detectable surge. At a still lower speed, as flow was reduced, first mild surge occurred followed by a zone of propagating stall, and then deep surge. These general characteristics were found to be typical of a number of radial bladed centrifugal compressors having diameters of from 5.5 to 14 in. Previous experience with these compressors indicated that with proper diffuser redesign the deep surge limit could be moved to a lower flow. The situation after this modification was made is shown in Fig. 6 where the new and old surge lines can be compared.

In addition to the design problems inherent in all compressors, special problems exist for special cases. For example, an automotive compressor often requires that accessories be driven from the front of the impeller shaft. In the light of possible alterna-

tives this is understandable but aerodynamics indicates a straight axial inlet would be better. Also, the impure atmosphere in which automobiles drive calls for filtration for the sake of maintaining performance and promoting long life. Silencing of the compressor has also to be considered. These last two considerations can introduce losses into the compressor operation.

Attempting to achieve maximum simplicity in a low cost application such as the auto engine also adds difficulties. (Attempts to incorporate aerodynamic refinements often lead to mechanically complex components of questionable reliability.) Cost cutting attempts such as trying to cast the impeller as a single unit usually aggravate attempts to maintain correct aerodynamics. In such complex castings it is very difficult to hold the tolerances that can be achieved with individual blade castings. Lack of such control can lead to undesirable boundary layer characteristics and premature inducer stall.

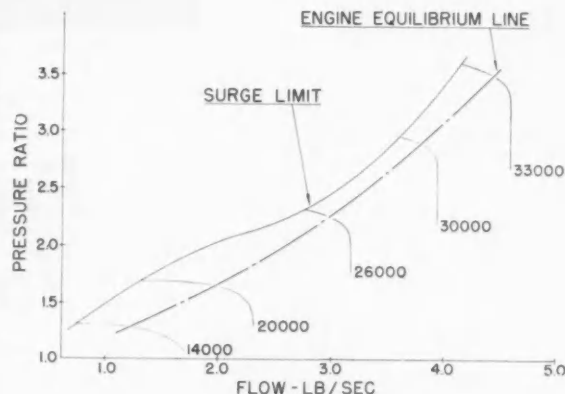


Fig. 5 — **THE COMPRESSOR PERFORMANCE MAP** shows how flow varies with pressure ratio for any speed. The compressor will surge when it operates to the left of the surge limit. When the engine is accelerating the surge limit is approached and may be exceeded if the surge margin is insufficient.

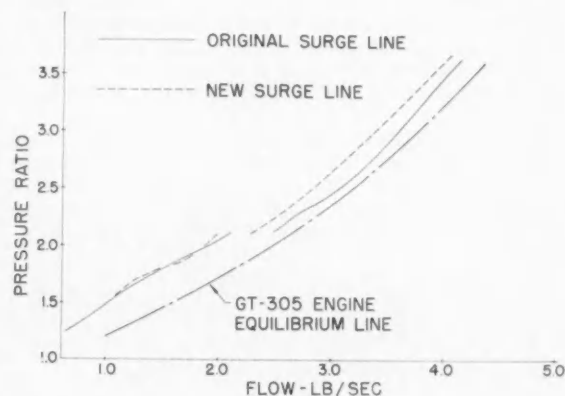
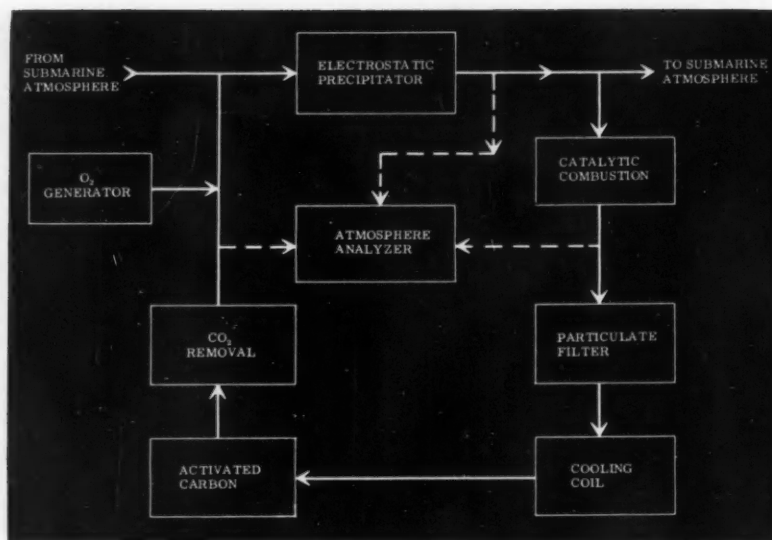


Fig. 6 — **PROPER DIFFUSER DESIGN** proved to be effective in extending the operating range of the compressor by shifting the surge limit.

Fig. 1 — Integrated system for atmospheric control.



Providing better air for bottled up men

Based on paper by

Eugene A. Ramskill

U. S. Naval Research Laboratory

ONE of the problems that arises when man is confined for an extended period in an enclosed space, whether it be a nuclear submarine or a space vehicle, is to keep the air fit for human consumption. In both cases, the atmosphere cannot be renewed from the outside, and thus it is necessary to devise means of keeping the air sufficiently pure, from within.

There are, basically, two problems involved:

- Keeping down the concentration of substances that are actually toxic, or even that make the atmosphere just plain uncomfortable for man. (In some instances, harm may also be done to equipment aboard, but this is a secondary consideration.)
- Keeping up the concentration of oxygen.

The magnitude of the problem of controlling the atmosphere in a nuclear submarine can be gleaned from a study of Table 1, which lists the substances identified or suspected of being present.

Integrated system

Many individual removal mechanisms have been devised to reduce the concentration of various

harmful substances to an acceptable level, and maintain oxygen at a high enough level. Fig. 1 shows how these various units can be gathered into an integrated control system.

The capacity of the electrostatic precipitator is greater than that of the other units, and only a portion of the electrostatic precipitator effluent is taken through the remaining units. The catalytic combustion step oxidizes CO, H₂, and most organic substances to CO₂ and H₂O. The particulate filter is located after the "burner" to remove any dusts and particulate matter coming from the burner primarily to protect the cooling coils. The cooling coils are used primarily to facilitate absorption in the activated carbon bed and remove any excess water. The air reaching the CO₂ scrubber should be essentially pure air, except for CO₂. Replenishment oxygen is added after the CO₂ removal. It is noted that the atmosphere analyzer can monitor the system at several points to determine its efficiency of operation.

Comparison between submarines and space ships

When one considers atmosphere control in submarines and space ships, one is immediately impressed with the likenesses.

It is to be noted that, for some time to come, it is expected that the atmospheric needs of the space

Table 1 — What's in Nuclear Submarine Atmosphere
Compounds Identified as Present

Quantitatively Identified		Qualitatively Identified in Trace Amounts	
	Highest Concentration Normally Found		Maximum Acceptable Concentration, ppm
Acetylene	0.5 ppm	Benzene	25
Ammonia	> 1 ppm (100) ^a	1-3-dimethyl-5-ethylbenzene	—
Carbon dioxide	1.1% (5000) ^a	Ethylene	—
Carbon monoxide	38 ppm (100) ^a	p-ethyl toluene	1000
Chlorine	1 ppm (1) ^a	Freon-114	5
Freon-12	70 ppm (100) ^a	Hydrogen chloride	—
"Hydrocarbons" (other than CH ₄)	25 ppm	Mesitylene	—
Hydrogen fluoride	0.3 ppm (3) ^a	Propane	—
Hydrogen	1.75%	Pseudocumene	5
Methane	118 ppm	Sulfur dioxide	200
Methyl alcohol	6 ppm (200) ^a	Toluene	200
Monethanolamine	< 1 ppm	o-xylene	200
Nitrogen	80%	m-xylene	200
Nitrogen dioxide	0.1 ppm (5) ^a	p-xylene	200
Nitrous oxide	27 ppm		
Oxygen	20%		
Stibine	1 ppm (0.1) ^a		
Water vapor	60% rel. hum.		
"Cigarette smoke"	0.4 µg/l		

^a In parentheses, max acceptable concentration, ppm.

Compounds Suspected as Present but not Identified

	Suspected Source	Max Acceptable Concentration, ppm
Formaldehyde	Oxidation of methyl alcohol	5
Mercury	Meters and gages	0.1 mg/m ³
Ozone	Electronic & electrical equipment	0.1
Acrolein	Cooking fats & greases	0.5
Phosgene	Degradation of freon	1
Hydrogen sulfide	Waste tanks	20
Radon, etc	Luminous dials	—
Triaryl phosphate	Hydraulic fluids	—
Sodium bisulfate	CO ₂ scrubber	—

Some Gases and Vapors Identified in Cigarette Smoke, and Presumed to Exist in Submarine Atmospheres when Smoking Is Allowed^a

	Max Acceptable Concentration, ppm		Max Acceptable Concentration, ppm
Acetylene ^b	—	Hydrogen cyanide	10
Acetaldehyde	200	Isobutylene	—
Acetone	1000	Methane ^b	—
Benzene ^b	25	Methyl alcohol ^b	200
Butadiene	1000	2-methyl furan	—
Carbon dioxide ^b	5000	Methyl chloride	100
Carbon monoxide ^b	100	Propylene	—
Ethane	—	Furfuraldehyde	5
Ethylene ^b	—	Formaldehyde ^b	5
Diacetyl	—	Propionaldehyde	—
Furan	—	Diethyl ketone	—
Isoprene	—		

^a Unlimited smoking is allowed in nuclear submarines.

^b Already present from other sources.

ship will more closely approximate those of the nonnuclear fleet-type submarine (which is seldom submerged for more than a few days at a time) than the nuclear submarine. Thus, for relatively short space flights, it will probably be more efficient to utilize consumable supplies rather than continuous-operation devices.

For example, chemical sources of oxygen and carbon dioxide absorbers will probably be more efficient on short space flights than a sulfate-cycle or an algal farm. There will come a time, however, when the continuous-operation devices will be re-

quired for space flight. Prior to that time, advantage should be taken of the various experiences on nuclear submarines.

While man requires only oxygen addition to and carbon dioxide removal from his atmosphere, many other substances can easily become a part of that atmosphere. Some of these substances can poison him, or otherwise reduce his efficiency. Some of these substances are very difficult to remove from the atmosphere.

To Order Paper No. 352D . . .

from which material for this article was drawn, see p. 6.

Radiation can ruin your

When designing for a nuclear radiation environment,
materials can be rendered useless in their
by radiation-produced changes of

Based on papers by

Mary Jane Oestmann and J. F. Kircher

Battelle Memorial Institute

and

J. W. Clark and T. D. Hanscome

Hughes Aircraft Co.

IMPORTANT among recent revelations about radiation effects on materials and equipment are the facts that:

- A rapid radiation dose rate can cause equipment malfunction even when the dose itself is small enough to permit human survival.
- Gamma radiation can cause permanent damage in organic materials, but hardly affects inorganic compounds, particularly metallic or crystalline solids.
- Semiconductors subjected to neutron flux have their electrical properties permanently changed. They also suffer transient effects from gamma radiation.

Radiation-caused changes of physical properties occur as the incident particle or wave dissipates its energy in the irradiated material. The basic mechanisms for this dissipation are:

- **IONIZATION**, producing a free electron and a positively charged atom or molecule.
- **EXCITATION**, where an orbital electron is raised to a higher energy state but stays bound to its parent nucleus.
- **DISPLACEMENT** of an atom.
- **CAPTURE** of a neutron, resulting in transformation of the nuclear structure.
- **SCATTERING** of the incident particle or photon and emission of secondary radiation.

The first two processes describe the way in which gamma radiation interacts with the exposed material. Fast neutron irradiation results in displacement and scattering, whereas thermal neutrons are responsible for the capture process.

Effects on materials

METALS generally show a greater resistance to radiation than do organic and semiconductor materials. Before any changes in physical or mechanical properties can be detected, fast flux levels of about 10^{19} n/cm² are required. For certain properties, though, such as magnetic, integrated fast fluxes of 10^{17} can produce an effect. The changes that do take place in irradiated metals are analogous to cold working effects, only less severe. Experimental data show that almost all the changes can be "annealed out," or they may be reduced at the start by irradiation at elevated temperatures. A summary of radiation effects on metals is given in Table 1.

GRAPHITE, the most widely used solid moderator, has its mechanical properties, notably, strength, hardness, brittleness, and impact resistance, improved due to radiation. However, electrical properties decrease as a result of radiation damage to the crystal lattice. The extent of radiation-induced change depends on the source of the graphite and its method of manufacture.

GLASS is most obviously affected in coloration due to gamma radiation. A high enough exposure may even cause physical disintegration to occur. To prevent loss of light transmission in applications such as transparent shielding windows, 1-2% tetravalent cerium lead may be added.

ELASTOMERS vary widely in their radiation resistance; different methods of preparation of the same material leading to variation in radiation effects. Elastomers having the most resistance to radiation are polyurethanes, adduct rubbers, and natural rubber. The most significant development in radiation resistant elastomers is the use of fillers, radiation resistant resins, and organic additives called antirads. These last are especially important

design

remember . . .

design application

physical properties.

since they allow retention of tensile strength and can extend by a factor of 10 the ultimate elongation of natural rubber-tread stocks.

Fluorocarbon rubbers exhibit low radiation resistance and are inferior to butyl rubber in this respect. The radiation stability of fluorocarbons is also quite markedly affected by environment. Their stability in air cannot be used to predict their stability in other media.

PLASTICS are generally equal or superior to elastomers in radiation resistance, but are inferior to metals and ceramics. Plastics having the highest stability are polystyrene, mineral filled phenolics and polyesters, polyethylene terephthalate, polyvinyl chloride, and polyethylene. It has been noted that aromatic structures provide the greatest stability, while the presence of quaternary carbon atoms leads to radiation instability.

Organic fluids

The radiation resistance of organic fluids can be modified to obtain a compromise of different properties by adjusting the composition. Advantage can be taken of the superior resistance properties of the aromatic nucleus in order to improve those organic materials having potential applications as fuels, lubricants, hydraulic fluids, and heat transfer fluids.

FUELS used for commercial jets, having the best stability, appear to be saturated petroleum fractions and synthetic fuels.

LUBRICANTS having a petroleum base show somewhat superior radiation resistance than those based on organic esters. It appears that the best compromise of stability, lubricity, and low temperature performance is offered by hydrocarbon fluids such as highly refined mineral oils.

HYDRAULIC FLUIDS for high-temperature applications, where pour point is not critical, can be polyphenyl ethers. The alkyl aromatics may be the best compromise as to pour point and stability.

HEAT TRANSFER FLUIDS for high radiation exposure are the terphenyls. At low exposures, the

Table 1 — Summary of Radiation Effects on Metals

Property	Radiation Effect
Yield Strength	Increased up to several hundred per cent in annealed materials and to a lesser extent in previously cold-worked or heat-treated metals
Tensile Strength	Increases up to 75 per cent for annealed and to a lesser extent in cold-worked metals
Ductility	Decreases by one-fifth to one-third for annealed and to a lesser extent for cold-worked metals
Elastic Constants	Limited data indicate little or no change
Creep Rate	Usually unaffected
Work Hardening	Decreases
Impact Strength	Decreases — ductile to brittle transition temperature raised by as much as 212 F
Fatigue Strength	Limited data indicate no effect
Hardness	Increases moderately, less than 100 Brinell
Damping Capacity	No change
Density	Decreases by as much as 0.2 per cent; can be considerable when gas formation occurs
Diffusion Coefficient	Limited data show slight increase
Electrical Resistivity	Increases by less than 10 per cent at room temperature
Phase Changes	Possible in certain systems
Microstructure	Changes observed in certain systems under selected conditions
Thermoelectric EMF	Little change
Thermoconductivity	Limited data show moderate decrease
Corrosion Resistance	Little or no change
Induced Radiation	Depends on concentration and cross section of components; cobalt containing alloys are undesirable
Dimensional Stability	Moderately affected except where induced radiation has occurred
Internal Friction	Limited data show little or no effect

Radiation can ruin your design

... continued

para isomer shows the highest resistance, while at higher exposures, the three isomers approach one another in stability.

Electrical and electronic equipment

Electronic equipment can malfunction due to the transient effects of radiation on the individual components. These effects appear and disappear with the radiation, affecting system operation even though no permanent damage may be produced. Hardening a system against this hazard consists of choosing components and circuit modules known to be resistant. Data has been obtained concerning the behavior of individual parts, and it is hoped that these will lead to a better understanding of system response. Until radiation-hard components can be developed, some trade-off with performance and some de-rating will be necessary.

Following are some component responses to irradiation:

SEMICONDUCTOR DEVICES have a lower reliability than most electronic devices. They show changes in conductivity, and current carrier mobility and number. Back resistance is decreased because of an increase in the number of carriers in the junction depletion layer.

TRANSISTORS behave like diodes in the sense that the observed transient phenomena can be attributed to conductivity changes. These are normally expressed in terms of changes in the current gain factor β and the zero bias collector current I_{co} .

ELECTRON TUBES are affected mechanically by damage to hard-borosilicate glass envelopes and to glass-to-metal seals. Other types of glasses and seals stand up better. Gas tubes are subject to ionization breakdown of the gas, which is of no consequence if the tube is operated in the discharge condition. Switch operation can be made relatively invulnerable by increasing the holding bias by a suitable factor.

RESISTORS show transient changes in resistance ranging from 1% for some carbon composition units to as much as 20% for some wire-wound types.

CAPACITORS are subject to dielectric leakage. The more resistant types employ inorganic dielectrics such as mica, glass and ceramic.

INSULATION may change conductivity by several orders of magnitude. Large effects are usually transient, but permanent damage resulting in degradation and deterioration of the materials can occur.

PRINTED CIRCUIT BOARDS undergo serious degradation during irradiation. Surface coatings can provide a stopgap for reducing ionization-current effects but further improvements are needed.

COAXIAL CABLES are susceptible to internal leakage and charge scattering. Both effects are small but become important in high impedance and low level circuits.

To Order Papers Nos. 339A and B . . .

from which material for this article was drawn, see p. 6.

Predicting tire performance by machine

Based on paper by

L. M. Morrish and R. R. Haist

Buick Motor Division, CMC

BUICK has built a machine for checking tires for roughness and shake by recording radial runout while eliminating the many car variables which have always complicated the interpretation of results.

The machine is an outgrowth of radial runout work performed on chassis rolls and the method bases on the hypothesis that motions produced by the first and second harmonic of the loaded radial runout curve would produce shake; that the motions produced by the higher order of harmonics (3rd through 10th) would relate to thump, roughness, and rumble.

Design of test machine

Fig. 1 shows the tire test machine. A spring load of 1200 lb is applied to the larger tires under test for the purpose of keeping tire deflections realistic; lesser loads are applied to smaller tires, but loads are always comparable to car conditions. The tire is loaded against the largest standard wheel (1/600 of a mile) consistent with reasonable loading height. Selection of a spring-applied load instead of a dead-weight load helps to keep the natural frequency of the moving mass far above the operating frequency range.

The tire motions and forces imparted to the car have been shown to be repetitive for each succeeding revolution, therefore it is a relatively simple matter, with the use of a computer, to analyze the quantity of each harmonically-related sine wave which makes up the complex motion. The quantity of each harmonic can be recorded and eventually correlated with an importance factor.

Figs. 2, 3, and 4 show runout amplitude, velocity, acceleration, jerk, and vibration power plots for a good tire, a tire with bad shake, and a bad tire for high-frequency problems (rumble and roughness).

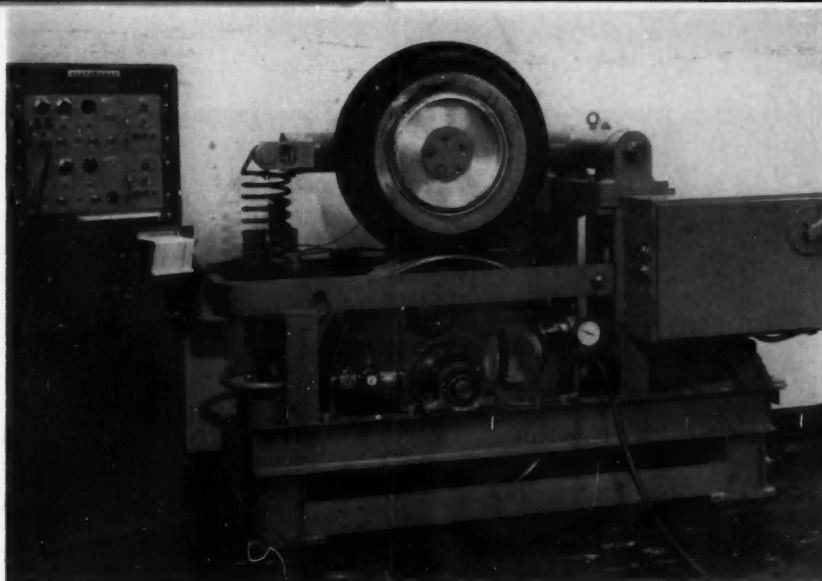


Fig. 1 — Loaded radial runout test machine for quick, accurate evaluation of tire roughness and shake.

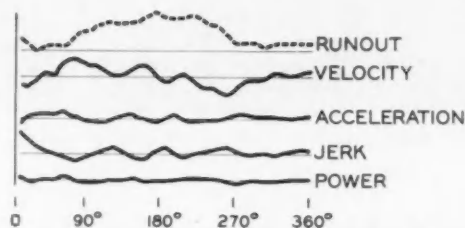


Fig. 2 — Runout and derivative curves for a ride-tested tire classified as GOOD.

A bad shake tire (Fig. 3) shows a predominance of first harmonic in the runout curve with little significance in the remainder of the curves. The bad roughness tire (Fig. 4) shows a predominance of higher harmonics that have phase relationship such that roughness will result. The bad thump tire will require that large quantities of the higher harmonics exist over only short spans of the tire periphery and not more than twice per revolution.

Significance of test work

Mean absolute vibration power seems to possess merit for correlation with human response. This quantity, reduced to a simple number representing the rectified average vibrational power for one revolution of a specific tire, could well represent the breakthrough necessary for simple qualification of tire roughness. Sudden changes in vibration power limited to not more than two per revolution could be the means for qualifying that specific form of roughness called thump.

The establishment of an actual inspection specification is difficult, but it is certain that a first harmonic peak-to-peak limit of 0.020 in. would be very desirable for minimized tire-induced shake. It is possible that an absolute value of vibratory power can indicate the limit of higher harmonics acceptable before rumble and roughness become objectionable.

To Order Paper No. 322E . . .

from which material for this article was drawn, see p. 6.

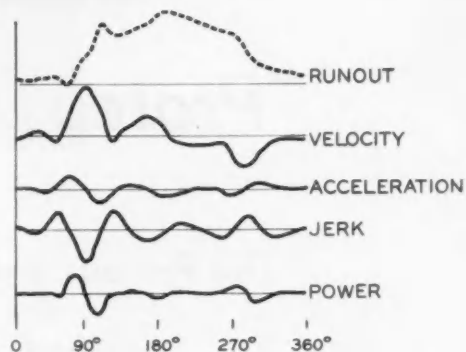


Fig. 3 — A ride-tested tire classified as A SHAKE EXCITER shows a predominance of first harmonic in the runout curve.

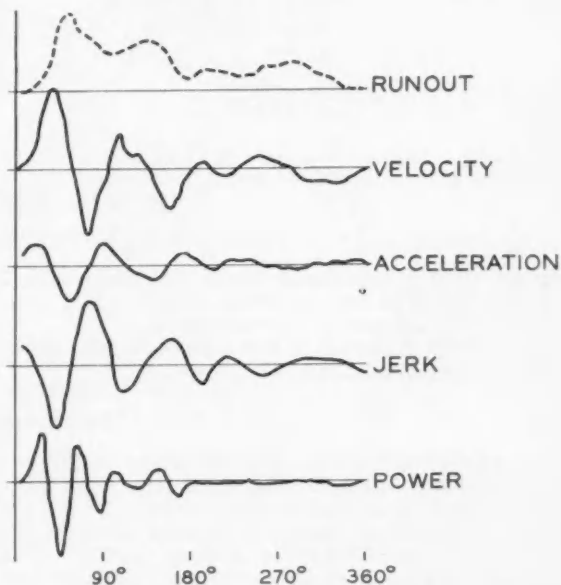


Fig. 4 — Runout and derivative curves for a tire ride-tested and classed as A NOISE EXCITER. The higher harmonics are predominant.

Fig. 1—Three Bristol Siddeley marine Proteus engines power the British Royal Navy's fast patrol boat of the "Brave" class, "Brave Borderer."



"Proteus" Goes Back to Sea!

The Proteus aircraft gas turbine, named for the Greek sea-god of many shapes, has now been adapted for use on fast patrol boats of the British Royal Navy.

Based on paper by

B. H. Slatter

Bristol Siddeley Engines, Ltd. (England)

THE Bristol Siddeley Proteus turboprop engine (now used in the Britannia airliner) has been successfully adapted to marine use.

It is being installed in two classes of fast patrol boats of the Royal Navy (Figs. 1 and 2).

The engine

A cross-section of the marine version of the engine is shown in Fig. 3. Air enters the axial compressor radially at the center section. There are eight combustion chambers located around the compressor, and there is a 4-stage turbine. The first two stages drive the compressor and the last two are mechanically independent and form the free power turbine.

Installing the engine in boats

During bench tests the engine was run on diesel fuel, with an appropriate amount of sea water injected into the engine to simulate more severe salt contamination than that likely to be experienced in service. These tests revealed that corrosion of the first-stage turbine stator blades occurred, but that it could be successfully overcome by application of a ceramic coating to the blades. Development work was also done to provide a configuration of intake duct splitter panels, which would combine the desired degree of silencing with effective water separation.

It was also felt desirable to provide inching motors on the engine to rotate the compressor and turbines slowly, to ensure that no brinelling of the ball and roller bearings would occur when the engine is not being used but may be subjected to vibration from other machinery.

The main features of the arrangement of the machinery in the Brave boats are shown in Fig. 4. Each



Fig. 2—Twin Proteus 88-ft fast patrol boat, "Ferocity," showing transom exhaust arrangement.

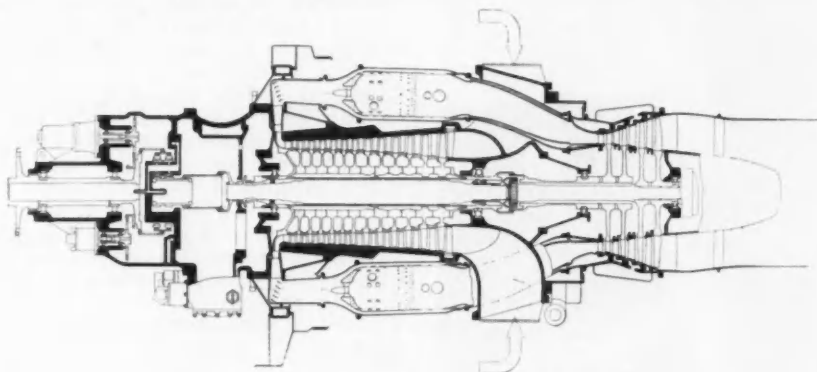


Fig. 3—Marine version of Proteus aircraft gas turbine engine. Type: reverse flow, free power turbine; rated at 4250 shp; output shaft speed 5260 rpm max; bare weight 2885 lb; air mass flow 45.6 lb-sec; compression ratio 7.32/1; length 111.95 in.; diameter 42.9 in.

of the three engines drives a propeller through a V-drive reverse and reduction gearbox, the engine output shaft speed being 5000 rpm. This output speed was necessitated by the V-drive arrangement and required that a new epicyclic primary reduction gear be fitted to the engine.

The machinery space is divided into two parts, the after space forming a plenum chamber supplying the intake air to the engines and connecting with a single air intake duct above the deck level. The engine exhausts are led out aft through the transom, the residual exhaust thrust making a small contribution to propulsion. The boats are powered

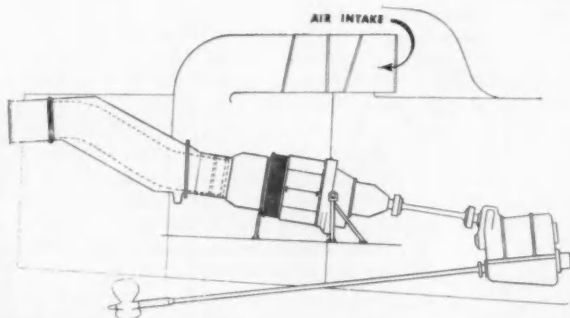


Fig. 4—V-drive installation in "Brave" boats. Each of the three marine Proteus engines drives a propeller through a V-drive reverse and reduction gearbox.

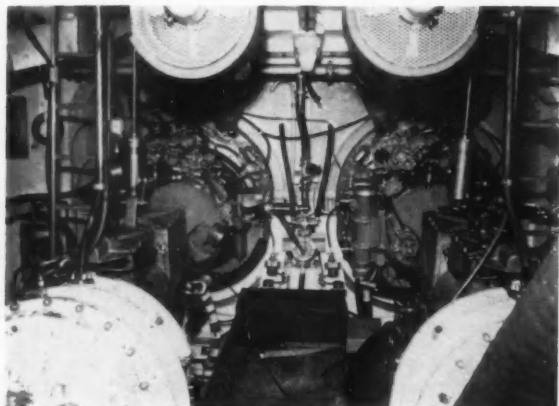


Fig. 5 — Engine room of twin Proteus fast patrol boat, "Ferocity."

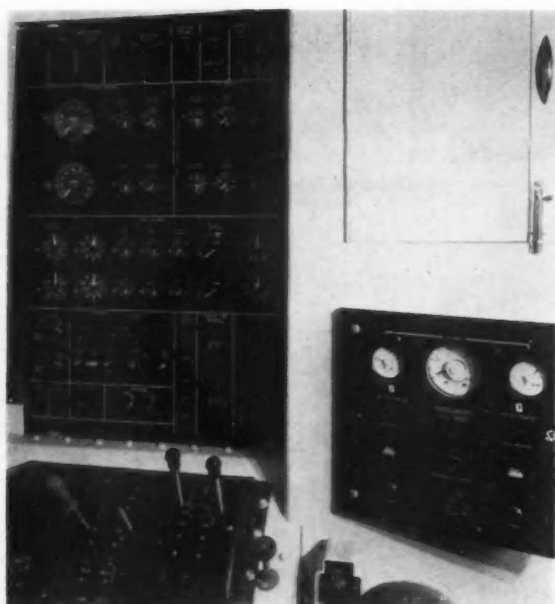


Fig. 6 — Controls and instrument panel at engineer's station.

"Proteus" Goes Back to Sea!

... continued

solely by their three Proteus engines, which give them a top speed in excess of 50 knots.

Fig. 1 shows that the air intake duct entry of the "Brave Borderer" is positioned aft of the bridge structure, which thus assists in preventing the direct entry of spray into the duct. Each engine is controlled by a single lever on the bridge, which also operates the ahead and astern gearbox clutches in such a way that the engine throttle is not opened until one or the other of the clutches is engaged.

The engine room of the twin Proteus 88 ft fast patrol boat, "Ferocity," is shown in Fig. 5. The layout is somewhat similar to that of the Brave boats, except that, in this case, two 150-hp diesel engines are fitted, driving into the V-drive reduction gearboxes in the main transmission. Clutches are installed between the Proteus engines and the gearboxes. Maneuvering, going astern, and long-range cruising are accomplished with the diesels. The Proteus engines provide high forward speed.

The transom exhaust and air intake entry aft of the bridge structure can be seen in Fig. 2. The compact instrument layout at the engineer's station, reminiscent of aircraft practice, is shown in Fig. 6.

Other installation configurations can be used, according to the shipbuilder's requirements. For example, controllable-pitch propellers can be employed to obviate the need for reverse gears and clutches and, in some cases, the secondary gearbox can be eliminated entirely by adopting a suitable primary reduction gear ratio and coupling directly to the propeller shaft.

Fig. 7 depicts a combined diesel and Proteus machinery layout. It indicates how gas turbines can be arranged to provide power boost in a ship which uses medium-speed diesel engines for normal cruising. In the example shown, the Proteus engines would deliver roughly twice the power of the diesel engines.

To Order Paper No. 347A . . .

from which material for this article was drawn, see p. 6.

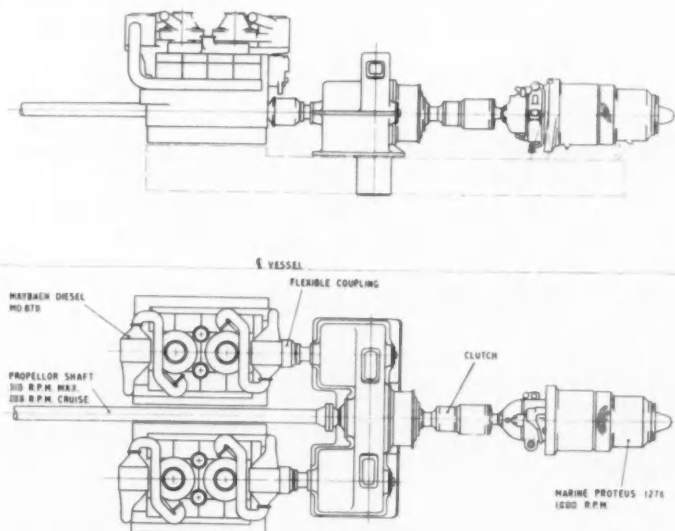
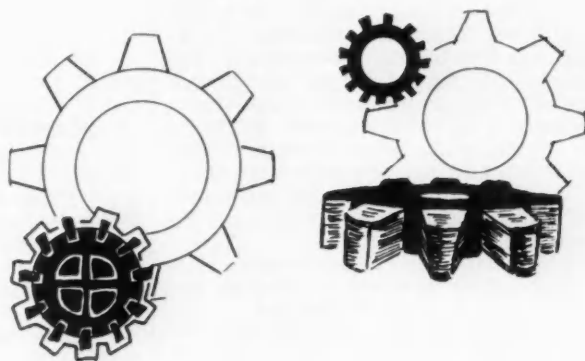


Fig. 7 — Combined Proteus and diesel-engine machinery layout.

Put realism in your gear design



Make sure tolerances are practical.

Call for standard equipment where possible.

Based on paper by

M. E. Samuelson

Barber Colman Co

QUESTIONS that a gear designer should ask himself when designing a gear include:

1. For relative dimensions, are the tolerances compatible?
2. Can standard or available tools be used?
3. Will the gear cutting department hold to the tolerances?

Compatible gear tolerances must be established for outside diameter and tooth thickness, root diameter and tooth thickness, tooth chamfer and gear tooth thickness.

A topping hob is often used to advantage on fine pitch gears such as 32, 48, 96 D.P. It will finish the gear O.D. during the hobbing operation. But to hold to a 0.001 in. tolerance on gear O.D. will require a depth of cut held to 0.0005 in. Let's take this a step further. Assume the same gear (64 D.P., 20 deg P.A., and 64 teeth) will have a -0.002 in. tolerance on dimension over pins. This tolerance can change the gear tooth thickness 0.0007 in. A ground topping

hob for this part will have a +0.0000 - 0.0003 in. hob tooth thickness tolerance. Adding the gear tooth thickness tolerance and the hob tolerance sums 0.001 in. Dividing this by the tangent of 20 deg gives 0.0027 in. Thus a minimum of 0.003 in. tolerance is needed on the O.D. of the gear based upon holding the 0.002 in. tolerance over wire.

Holding a tolerance on root diameter for a low pressure angle gear can be difficult. Consider a 12 deg P.A. gear with +0.000 - 0.005 in. tolerance on root diameter. The tolerance appears to be adequate for the part. However, in most cases the gear tooth thickness is verified and proven first. With a tolerance of -0.002 in. over pins the tooth thickness can vary -0.0009 in. The non-topping hob will have a -0.001 in. tolerance on hob tooth thickness. It is then possible for gear tooth thickness to vary $0.0009 + 0.001 = 0.0019$ in. Dividing 0.0019 in. by the tangent of 12 deg we get 0.0094 in. which is the minimum root diameter tolerance.

O.D. tooth chamfer is commonly used on gears finished by shaving. The gear designer can make it tough for the hobbing operation by imposing a close tolerance on the chamfer. At times, a tolerance of 0.001 in. is shown on gear chamfer size. Such a

gear design

... continued

tolerance may be incorrect for the gear tooth thickness variation allowed.

When investigating variations in chamfer, tolerances must be recognized for (1) gear tooth thickness (2) gear O.D. (3) hob tooth thickness (4) location of ramps on hob tooth. Theoretically, the maximum chamfer is produced when a gear having the maximum O.D. is cut to minimum tooth thickness using a hob which has minimum tooth thickness and minimum dimension to start of ramp. Thus, it is possible to hob a minimum chamfer with minimum gear O.D., maximum gear tooth thickness, maximum hob tooth thickness, and maximum dimension to start of ramp.

The theoretical variation in chamfer can be 0.010 in. or more. In practice, however, a tolerance 50-60% of the total calculated is more realistic.

Too close a tolerance on chamfer will limit the range of teeth one hob will be able to cut. For example, if a 7 D.P., 20 deg P.A. hob produces a 0.0125 in. radial chamfer on a 20 tooth gear, the same hob will produce a 0.0175 in. radial chamfer on a 37 tooth gear. Therefore, a close tolerance increases the number of hobs required to cut a range of gear teeth. At lower ranges of tooth numbers the change is more pronounced than at the higher range of tooth numbers.

Gears should be designed for standard hobs where possible. Some shaft pinions have a bearing surface or shoulder adjacent to the pinion. Often, this restricts the hob to a small diameter and necessitates use of a shank-type hob. This hob will cost about 20% more than a shell-type hob with standard bore. And, a shank-type hob may not lend itself to full automatic sharpening.

Standard topping gear hobs aren't available in all pitches. Standard hobs are designed to cut standard gear tooth thickness and standard O.D.

When topping hobs are used and a change in gear tooth thickness is required, it is also necessary to change the gear O.D. This is pertinent when hobs on hand are to be used for new gear design.

The gear designer should be familiar with the accuracy of production hobbing equipment. Often the equipment can't meet the accuracy required by design. One particular design called for a precision #1 gear. This gear allows a 0.001 in. total error. Trouble was encountered—the reason: 0.015 in. wear in the hob arbor.

Sometimes a gear and housing are designed integral, or it may be a gear and a flange. The designer must make sure that the diameter of the housing or flange is within the capacity of the hobbing machine. Interference on the machine can cause extensive damage.

To Order Paper No. 333C . . .

from which material for this article was drawn, see p. 6.

New adhesive raises hope for

Based on paper by

Samuel J. Dastin and Philip Rosenberg

Republic Aviation Corp.

A NEW, recently tested "composite adhesive" raises hopes that adhesives can be used to produce lightweight, high-strength, solid rocket motor cases. The "composite adhesive" differs from the conventional type, in that it has a varying shear modulus.

Crudely prepared samples of the "composite adhesive" have demonstrated failure at 3900 psi on a 6-in. overlap, as against failure at 3100 psi for the best available conventional adhesive. This 25% higher load-carrying capability gives increased strength in an important area, since failure occurs in the adhesive rather than the metallic components. With this greater adhesive strength the walls can be stressed to a higher level than the 250,000 psi allowable with conventional adhesives.

Adhesive development

Early tests showed the importance of high-shear flexible bonding agents. A rigid liquid epoxy adhesive tested on long lap tensile shear specimens, and then chemically modified for increased flexibility, and retested, gives the results of Fig. 1. At the 40% flexibility point a maximum load carrying capability is indicated. Beyond this point the allowable load is lowered since the inherent high shear capability of the rigid epoxy is reduced by flexibilization.

Mathematical investigation of the incremental stresses and strains within the adhesives, substantiate the test results. The shear stress distribution within the joint is the controlling factor on long lap bonds, as the typical shear stress diagram of Fig. 2 shows. Further testing has shown that an adhesive would have superior load carrying capability if its shear modulus could vary within the joint, with a maximum at the center of the joint and gradually reduced toward the ends. This would allow for the greater elongations at the ends of the joint under load.

Case fabrication

Fig. 3 shows a typical cross section of an experimental motor case design which is essentially a series of overlapping rings. The metallic rings are seamless, machined, high-strength, hot work, die

Adhesive-bonded rocket cases

steel. The minimum yield strength is 240,000 psi and the ultimate tensile strength is 280,000 psi.

The structural adhesive carries the longitudinal loads while the metallic rings resist the hoop loads; in cylindrical vessels the hoop load is twice the longitudinal load. The case is designed for an internal pressure of 1200 psi. The overlap needed, to allow the adhesive to function at the required stress level, was determined to be six inches.

The adhesive is a dry film type, inactive until heat and pressure are applied to cause flow and chemical conversion to a non-fusible, non-soluble, inert solid. It is applied over the inner rings at room temperature. The outer rings are thermally expanded and then slipped over the adhesive layer on the inner rings. Accurate measurement of the ring sections insure a controlled gap clearance which serves to apply a predetermined pressure on the adhesive resulting from the shrink-fit bonding procedure. After assembly the case is heated in an oven to cure the adhesive.

To Order Paper No. 330C . . .

from which material for this article was drawn, see p. 6.

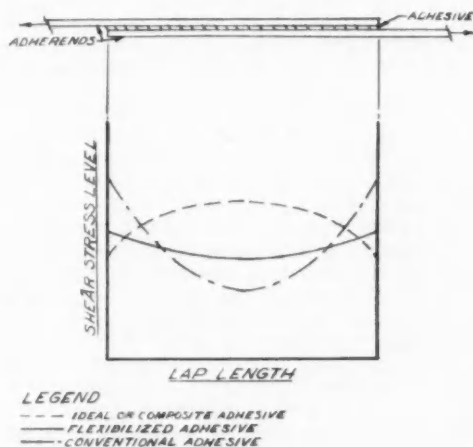


Fig. 2—Shear stress distribution in a long lap joint. The best adhesive would be one having a maximum shear modulus at the center of the joint, gradually reducing toward the ends. The resulting stresses for this condition are best approximated by the flexibilized adhesive.

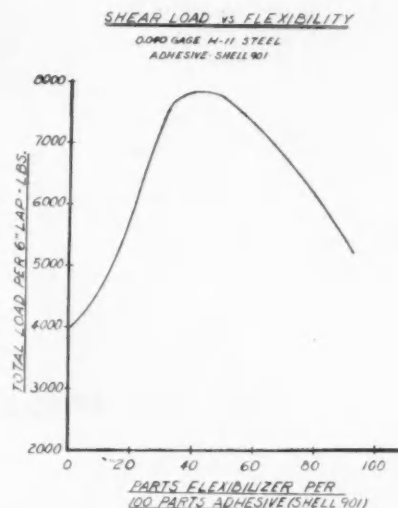


Fig. 1—Shear load variations as flexibility changes. Chemical modification of the adhesive by adding a flexibilizer allows the load carrying ability to be enhanced. A maximum strength is reached at the 40% flexibility point.

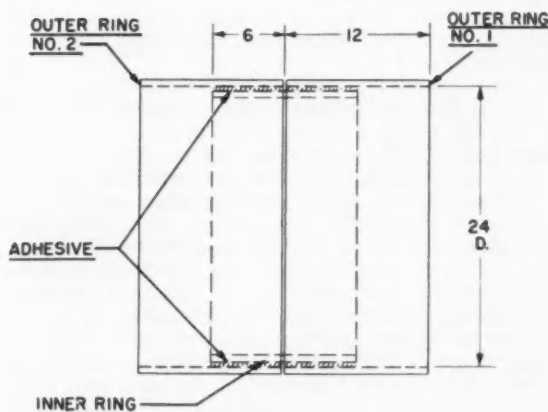
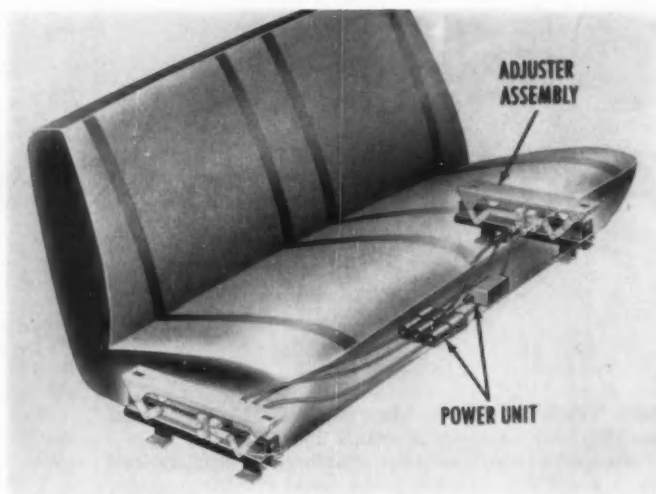


Fig. 3—Test motor case construction. The case is actually a series of overlapping rings, bonded with structural adhesive. Close control of the clearance gap helps fix the pressure on the adhesive during the bonding process.

Fig. 1 — Typical design of 6-way power seat adjuster as used on United States passenger cars.



Typical power seat

... illustrates design and principles of operation of 6-, 4-,

Based on paper by

David D. Campbell

Fisher Body Division, CMC

A SINGLE-MOTOR, transmission operated seat adjusting unit is the type commonly used in United States passenger cars for 4- and 6-way adjusters.

The industry has tried many different types, however, in the two decades since seat-adjusters first made their appearance on production cars. The first power seat adjusters were generally hydraulic. They were replaced by many different types of electric-powered units. Coordination of the two sides of the power adjuster was first accomplished by using heavy torque rods. As the overall passenger-car height was reduced, space was not available for the large rods, and they have given way to cables in the now generally used design shown in Fig. 1.

Currently, three types of power seat adjusters are offered as options by passenger-car makers: the 6-way, the 4-way, and the 2-way . . . each being exactly what the name implies.

The 2-way adjuster moves fore and aft horizontally. The 4-way moves the seat directly up and down in addition to fore and aft. The 6-way has six basic motions: up and down at the front; up and

down at the rear; and fore and aft. It allows the customer to tilt the seat at various angles to increase the seating comfort to suit personal desires.

In all of these types, designers recognize the importance of having them satisfactory when NOT in use as well as when in action. One designer recently emphasized the when-not-in-use time as of most importance. "The total expected running life of a seat adjuster," he points out, "is 30 hr or so. Most of its life is spent as a rather expensive spacer between floor and seat. . . . So, it MUST be free from rattles and shakes and horizontal movement during speed change."

Aiming for freedom from rattles, some designers are finding ways to reduce the number of different stampings needed and are developing more and more components that can be made very accurately. Seat looseness is now measured in thousandths rather than thirty-seconds of an inch. Die-casting and other methods of manufacture are getting increased attention for seat-adjuster parts.

Analysis of a 6-way adjuster — which offers all motions — permits clear understanding of how the 4-way and 2-way mechanisms are achieved. The two basic parts of the adjuster — the power unit and the adjuster assembly — are shown in the illustration of the six-way unit — Fig. 1.

The power unit consists of the motor and gearbox.

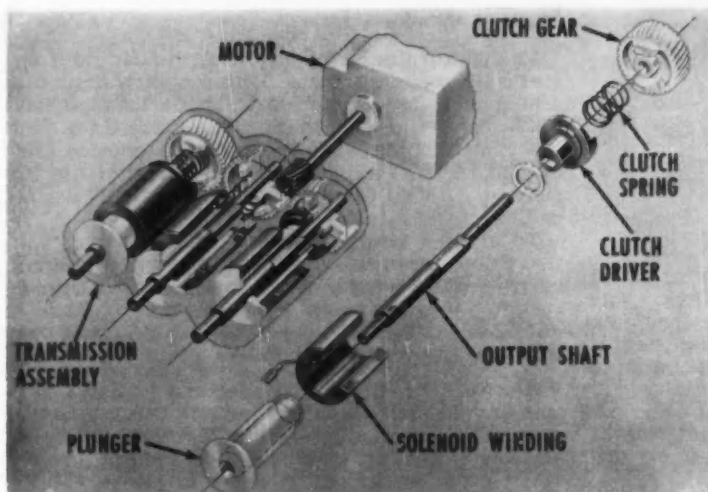


Fig. 2.—Power unit consisting of motor and solenoid gearbox of typical 6-way power seat adjuster.

adjuster

and 2-way units as used in today's U.S. passenger cars.

It is located off-center near the middle of the seat, to get tunnel clearance.

The two adjuster assemblies, located at the outboard edge of the seat, can be called the motion unit. These two units are connected by flexible cables and transmission to the adjuster assemblies. The cables guarantee that the two adjuster mechanisms always move in unison.

Power unit

A single-motor, solenoid-clutch drive unit, like the one shown in Fig. 2, is common to most of today's passenger-car seat adjusters. This power unit consists of a motor and a gearbox which contains three solenoids. The armature shaft turns a pinion gear, which drives three additional gears on individual shafts. These gears are connected to three dog clutches operated by solenoids.

The dog clutches are normally in the disengaged position. When the car rider operates the selector switch to cause the adjuster to move, two individual circuits are energized. The motor operates, and one or more solenoids are energized. This causes the dog clutch to engage and lock the shaft in a driving position. The pinion gear drives the shaft, locked by the dog clutch, which turns the flexible cable.

The cable is connected to the motion mechanisms (the adjusters) located on either side of the seat.

Since there are three solenoids, three separate motions may be achieved from the single motor. By reversing the motor, the three motions can be made bi-directional for the total of six motions required.

Adjuster mechanism

The motion mechanisms of adjusters commonly used consist of two separate bellcrank arrangements for the front and rear vertical movements—and a track for the horizontal.

The 2-piece track arrangement used for the horizontal is shown in Fig. 3. One piece of the track is secured to the floor; the other to the seat. A gear rack is pierced into the lower track (the one secured to the floor) and a pinion drive gear assembly is secured to the upper track (the one attached to the seat). When the pinion gear is driven by the worm on the end of the flexible shaft, it moves along the rack and causes the seat to move fore and aft.

Vertical motion is provided by individual bellcranks located at the front and rear of the adjuster, as shown in Fig. 4. A gear nut, which travels back

Power seat adjuster

... Continued

and forth on a stationary jackscrew, is attached through a link to one leg of the bellcrank. The flexible cable from the power units causes the gear nut to rotate and travel on the screw. As the nut moves back and forth, it causes the bellcrank to rotate and lift or lower the seat.

An individual jackscrew, gear nut, and bellcrank arrangement are located at the front and rear of the adjuster to accomplish the independent vertical motion at the front or rear of the seat.

How it works

To operate the 6-way adjuster, the car rider operates the selector switch. Thus, he starts the motor and engages one or more drive gears through solenoid-operated dog clutches. The gears drive flexible cables connected to the individual motion linkages at the seat adjuster. Coordination of the two sides of the adjuster is achieved by the flexible cables.

To make a 4-way adjuster from the 6-way unit, just delete one of the solenoids at the power unit and rearrange the front and rear bellcranks at the adjuster so they are driven by one gear nut ... and to get a 2-way adjuster, delete the gearbox at the power unit and the vertical bellcranks at the adjuster.

Paper No. 318A, from which material for this article was drawn, includes similar analytical descriptions of currently used power-operated windshield wipers, window regulators, door locks, deck lids, and convertible-top actuators. **To order turn to p. 6.**

Fig. 3 — Two-piece track arrangement used for horizontal motion adjustment of typical 6-way power seat adjuster.

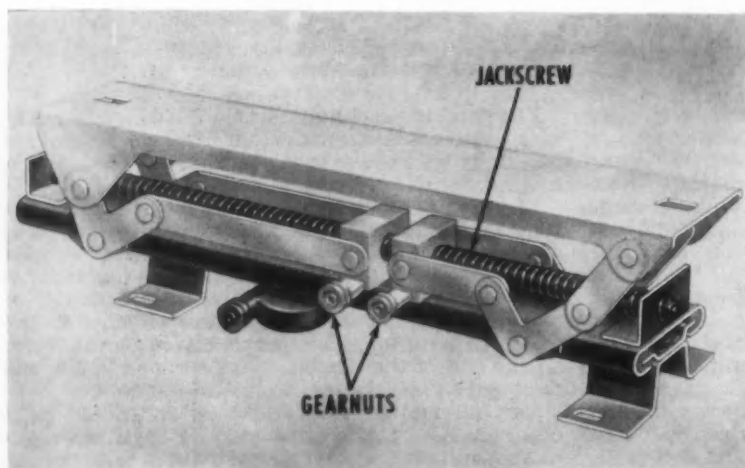
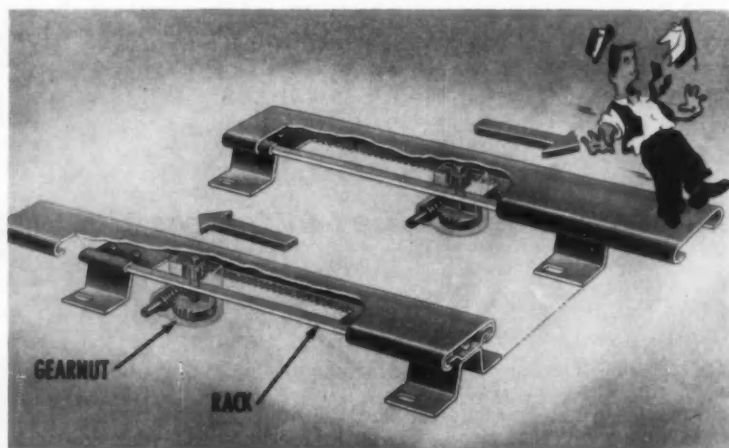


Fig. 4 — Individual bellcranks, located at front and rear of 6-way adjuster, are used to provide vertical motion adjustment.

Says "No" to Metric For Entire Economy

Based on paper by

ROY P. TROWBRIDGE

General Motors Corp.

MOTIVATIONS for "going metric" are insufficient to justify conversion of our entire economy. Segments of science, engineering and industry which can gain commercial or other advantage by going to the metric system should do so. However, those who do should not feel the necessity to crusade for converting others upon whom conversion would place a serious handicap.

The primary reason for converting to the metric system is greater precision, says an astronomical source. In reply one can say that no measurement system is more precise than another. The ability to measure or compare accurately is not dependent on the measurement system used.

The metric system has been said to offer simplicity. This is true. However, the main simplification derives from decimalization which can be used in the English and U.S. systems, particularly in machine design and manufacture, equally as well as in the metric system.

Proponents of the metric system lay particular stress on the interrelationships between the units for volume, mass and energy. This is a commendable feature, particularly useful in the scientific field, but it offers little real advantage to the more practical aspects of design and manufacture and, as far as one can see, no advantage to the general public.

What We Should Do

We in the U.S. should promote worldwide acceptance of our proven physical standards rather than convert to standards which do not measure up to ours in quality, practicability, and proven value. We should be concerned with future acceptance of inch-conceived and manufactured products in metric countries, particularly with respect to standard features such as screw threads, bolts, and nuts, pipe sizes, and the like. The importance to U.S. manufacturers of maintaining existing measurement units cannot be overemphasized. To change from one set of measurement standards to another would involve colossal expense and create years of confusion. Its affect on our defense system would be to give unfriendly powers an immense advantage.

The two measuring systems have coexisted for many years and they will continue to for many years to come, but with ever increasing under-

standing of the individual applicability and appreciation of the justification for both systems by all concerned.

■ **To Order Paper No. 287C . . .**
from which material for this article was drawn, see p. 6.

Let's Tackle Unit Systems Problem Now

Based on paper by

C. F. KAYAN

Columbia University

IF really universal unit systems of measurement are ever to be brought into being, a step by step approach will have to be made. To make a start in the right direction, here is an 8-point program advocated for the United States:

1. Decimalize the pound and the inch and eliminate tedious mixed measurements.
2. Revise elementary school arith-

metic programs and use decimal values. This will lay the necessary groundwork for other change.

3. Eliminate ambiguous terms such as gallon and hundredweight.

4. Expand the use of metric terms in common use to "condition" the public for future changeover. Weather maps already use the "bar" of the MKSA system; the Weather Bureau could just as well use Centigrade and also Fahrenheit when stating temperatures.

5. Ban the archaic word "horsepower" and substitute the kilowatt; eliminate the "refrigeration ton" and use instead "kilowatts of refrigeration effect." In time, the watt-energy term could be used for heat-transfer operations.

6. Develop dimensionless presentation of experimental data, with citation of basic reference values in a variety of unit systems. This would cover simple ratio values, composite relative values, and so-called dimensionless criteria.

7. Revise the teaching of engineering mechanics, with emphasis on the use of absolute-system philosophy based on mass as a basic unit and force as a derived unit; rather than on the gravitational system, using force as

Defense Department Stand on Metric System Use

—From statement by

John J. Riordan and Charles J. Brzezinski

Office of Assistant Secretary of Defense (Supply and Logistics)

THE Department of Defense is not in a position — even if it wanted to be — to play the role of protagonist in initiating conversion to metric measurement. It is but one element in the U. S. economy.

It can, however, accelerate progress toward conversion should decision for such a conversion be made in a particular industry, or throughout the whole economy. It buys about \$15 million of supplies each year; has over 3,500,000 different items in its Federal Catalog System. As a big customer in practically every industry, it can retard or encourage conversion to the metric system.

Should industry ever adopt the metric system, the Department of Defense would be particularly concerned with:

- (a) Impact of such conversion on industry's capability to produce adequate quantities of supplies in metric units.
- (b) The complex logistic problems related to phasing out of English units.

Granted the inherent technological merits of the metric system, it would appear that progress in its adoption can best be made by evolutionary progression, industry-by-industry, rather than by an *in-toto* industrial approach.

■ **To Order Paper No. 287D . . .**
from which material for this article was drawn, see p. 6.

the basic unit along with gravity-dependent weight.

8. Promote "bilingual" and "duo-philosophic" operating skills in varied unit systems for those "intellectual-elite" engineers working in the international engineering sciences. This includes particularly the MKSA system. Such an objective could be encouraged in the same manner as is foreign language facility.

■ **To Order Paper No. 287A . . .** from which material for this article was drawn, see p. 6.

Metric System Belongs In Math Education

Based on paper by

A. W. JACOBSON

Executive director, Detroit Research Institute

CHANGE to the metric system will be a gradual one and the best approach to its adoption is to decimalize our own units of weights and measures. In the meantime, the metric system and its various units and conversion factors should be taught to school children, especially at the high school level.

Mathematics has become increasingly important to our society and there is now a compelling social responsibility to improve and extend mathematics education at all levels. Progress in the teaching of mathematics should be accelerated, beginning with the lower grades, and brought into closer relationship with the practical needs of our technological society. A basic requirement is that mathematical talent be available in depth and this implies a more extensive and up-to-date training for those who terminate their education at high school.

One way to foster accelerated mathematics learning would be to teach decimal fractions at an early stage and postpone and minimize the teaching of common fractions. For classroom use there should be such devices as scales in which the inch is divided into tenths, and in which the smallest division represents the fiftieth part of an inch or 0.02 in. The decimalization of the inch, for example, does away with the need for conversion and provides a scale more suitable for measurement than one in which the inch is divided into 64 parts.

Following this we need teachers who know and understand these devices. Thus, a better and closer interchange of ideas between our teachers and people in industry and business is essential.

■ **To Order Paper No. 287B . . .** from which material for this article was drawn, see p. 6.

Ionizing Radiation Can Modify Polymers

Based on paper by

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Wright-Patterson Air Force Base

THE INTERACTION of ionizing radiation with polymers produces effects such as those shown in Figs. 1 and 2. Just as in other systems, the initiating step is to break a chemical bond. The broken fragments can interact in various ways—to recombine in new arrangements, to form crosslinks, or to be degraded into smaller molecules. For example, the familiar plastic material, polyethylene, when irradiated for controlled doses, undergoes primarily the crosslinking mechanism. As a result, it acquires higher hardness and temperature resistance. An existing commercial application of these properties is the crosslinking of polyethylene insulation on electrical wires so that they may be used at substantially higher temperatures. Crosslinked polyethylene containers may be subjected to moderately high temperatures, as in cooking and

sterilization.

Fig. 2 shows typical classes of copolymers—hybrids composed of two or more different kinds of monomers. These monomers may be caused to unite in a random fashion in blocks of homopolymers or in side chains grafted to the main polymer chain. It may be possible to use radiation to marry two incompatible polymers, such as nylon and cellulose, to obtain the desirable characteristics of both in the finished material.

An interesting application of the block copolymer technique has been used with teflon. Teflon is an extremely chemically resistant polymer, which cannot be dyed by attaching colored substituents to the polymer chain. However, the teflon may be irradiated on the surface or throughout the system and exposed to selected dye-accepting monomers, with the result that this material is labeled with any desired color. Similarly, polystyrene may be grafted to the surface of teflon film so that the otherwise unbondable teflon can be attached to other substances, while the other side retains its chemical inertness and high temperature resistance.

■ **To Order Paper No. 294D . . .** from which material for this article was drawn, see p. 6.

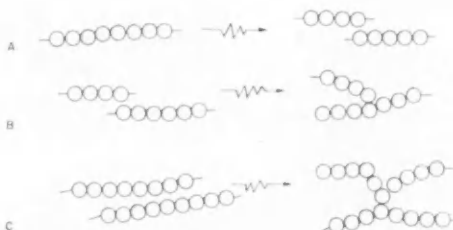


Fig. 1—Effects of radiation on polymers. A. Degradation into smaller molecules. B. Recombination into new chain structures. C. Crosslinking.



Fig. 2—Formation of copolymers. A. Random combination of homopolymers. B. Block copolymers—groups of homopolymer fragments joined together. C. Graft copolymers.

Costs Fix Choice of Flywheel Alternator

Based on paper by

GLEN A. GUERNSEY

Wico Ignition Div., Globe-Union Inc.

FLYWHEEL alternators for small engines may well represent one-fourth of the total engine cost. Consequently their design must often be compromised to maintain economy. Depending on the particular application, steps must be taken to get acceptable operation at a lower cost. Typical applications for the flywheel alternator are: motor scooters, ride-on lawnmowers, and outboard motors.

For the motor scooter, voltage regulation presents a serious problem. Good lights at low engine speed are required, but they must not burn out at high speed. One unit for this application consists of six magnets die-cast in a rotor ring which is bolted to the engine flywheel. A die cast aluminum stator plate carries the laminated iron structure and coils for lighting and ignition. The unit is shown in Fig. 1. Ample magnet, steel, and copper are used to ensure good low-speed performance, but in such a way that the output flattens with speed. Because the taillight requires less power a shunt is required in the taillight circuit to obtain proper performance there. This results in better regulation than the more common practice of increasing the air gap at the taillight coil core.

This unit may be used when the scooter is equipped with battery operated lights or electric starting. In this case the lighting coils are replaced by four similar charging coils which charge a 12-v storage battery through a selenium rectifier.

Ride-on-lawnmowers are extremely difficult to satisfy with low-cost alternators. This is because they normally employ small lead-acid storage batteries that have less discharge capacity and greater sensitivity to overcharging than standard automotive batteries. The homeowner who uses his lawnmower only a few hours a

week would require a higher charging rate than the professional who operates his perhaps eight or more hours a day. A low coming in speed is not of prime importance since the engine is generally governed at fairly high speed.

One approach to the problem might be to use an easily regulated, d-c-excited, wire-wound alternator. However, this makes the use of a battery mandatory for engine operation. Besides, the unit is relatively costly. A lower-cost unit for the same application utilizes permanent magnet excitation and bifilar wound charging coils which permit full-wave rectification with only two silicon rectifiers. Removing one of the rectifiers reduces the charging rate by approximately 40%, making the unit adaptable for use by both the professional and the homeowner. The unit may also be used without a battery.

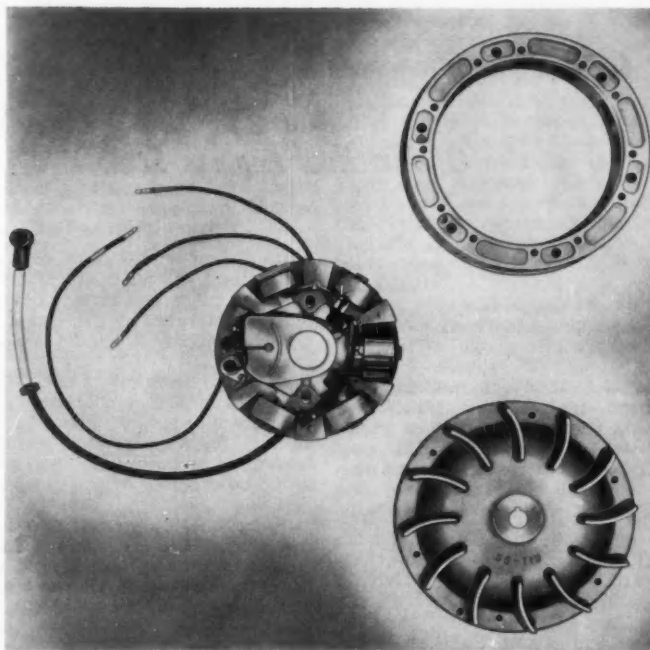


Fig. 1 — Motor scooter flywheel alternator. The rotor ring contains six magnets and is bolted to the finned, cast iron flywheel. The stator provides separate circuits for magneto ignition, headlight, stoplight, and taillight. A shunt on the taillight circuit protects the light.

For outboard motor applications the coming-in speed is important to avoid draining the battery at idling speed. The lowest cost approach which is likely to be acceptable requires; a reasonably low coming-in speed (700-1000 rpm), 6-8 amp top output (possibly adjusted upward), and no regulation.

A slightly higher cost approach would have a coming-in speed low enough to compensate for battery drain at idle. The charging rate is the same as above, with no regulation.

Where higher costs can be justified, the coming-in speed can be such as to allow at least a trickle charge of the battery at idle. The output would be at least 20 amps at as low an engine speed as possible, with full regulation.

■ **To Order Paper No. 276D . . .** from which material for this article was drawn, see p. 6.

Electric Vehicle Staging Comeback

Based on paper by

H. C. RIGGS

Electric Storage Battery Co.

INTEREST in electric propulsion for passenger cars and trucks has revived. Among the developments prompting it are:

- A 50% increase in power output of storage batteries per unit of weight and

space during the past six years.

- Improved motor and controller design providing faster acceleration and high rates of speed.

- Rising gasoline prices.
- Lower operating costs for electrics in their proper field.

- Absence of noise and fumes.
- More short-haul travel in densely populated suburbs.

The advent of the fuel cell will not

change either initial or operating costs materially. It will give longer life and slightly reduce maintenance costs, perhaps even lower weight and require less space. If fuel is readily available, the fuel cell battery can provide for long-distance and high-speed electrics. But the coming of practical fuel cells looks to be still five years away.

(Material in this article is drawn from one of 12 papers included in SAE Technical Progress Series, Volume 3: Storage Battery Symposium—1961. To order this publication, TPS-3, see p. 6.)

Combustion Phenomena

Of Multifuel Engines Studied

Based on paper by

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AG (Germany)

A COMPARISON of multifuel engines—including an M.A.N. engine with the "M" combustion system (*SAE Journal*, September 1955, pp. 18-25)—leads us to the following conclusions:

- The combustion system of a multifuel compression engine must have the special characteristic of effectively moderating the initial rate of heat release without adversely affecting the later phases of combustion. Measurements of a prechamber and an M.A.N. "M" engine utilizing various fuels show to what extent the above formulated requirements are met by both systems. Test results can be evaluated by means of reaction kinetics, uncovering in addition the interrelation of the diesel and the Otto engine knock phenomena.

- The particular feature of the M.A.N. "M" system—wall deposition of the fuel—definitely does not present a limit with regard to high-speed diesel operation. Tests carried out with high-speed diesels, as developed by M.A.N., showed extremely satisfactory results. Independent investigators have established additional theories explaining and supporting the above test results.

- Detailed consideration has been given to the influence of the compression ratio, stroke/bore ratio, and com-

bustion chamber design on smoke limit and output. As far as the M.A.N. "M" system is concerned, its multifuel capability is improved by increasing cylinder displacements and stroke/bore ratios.

- Leakage in injectors and pumps of multifuel engines is noticeably greater when gasoline is used. The reduction in output (for a given rack setting) is, therefore, proportionally higher than would be expected by the difference in fuel density alone. Increased leakage rate also entails increased injection lag.

- Recent M.A.N. designs incorporate pistons of high silicon content to improve temperature levels and temperature distribution, aiming at the elimination of local stress concentrations and at best conceivable combustion characteristics. These new pistons have been extensively tested on a fatigue testing machine.

Shrouded valves utilized in former M.A.N. designs are now being replaced by specially developed intake ports, generating the necessary swirl ratio at lower pressure losses. (See Fig. 1.)

- Cold-starting difficulties formerly encountered with "M" system engines have been successfully overcome. The M.A.N. multifuel engines now in quantity production exhibit outstanding cold-starting abilities, even with gasoline at temperatures as low as -40 F and cranking speeds no higher than 60-70 rpm.

■ **To Order Paper No. 296A . . .**
from which material for this article was drawn, see p. 6.

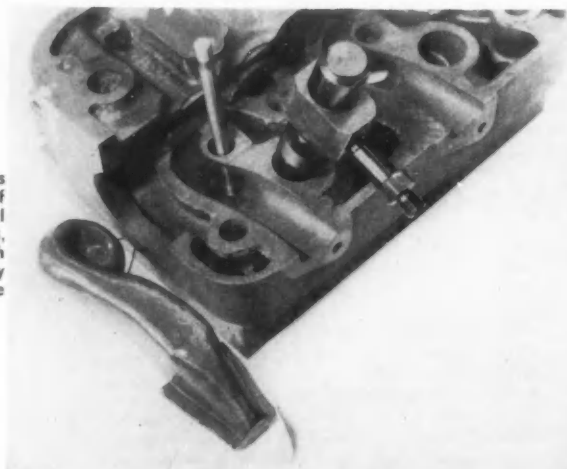


Fig. 1—M.A.N. engines now have, instead of shrouded valves, swirl producing intake ports, as shown above, which provide the necessary swirl at lower pressure losses.

Reliability Is Everybody's Business

Based on report by secretary

R. J. JUVE

Chevrolet Division, GMC

RELIABILITY is the business of everybody associated with the designing, manufacturing, and servicing of the automobile. It is not one department's responsibility.

Reliability is "the mathematical probability that a device will perform satisfactorily for a specified time under specified conditions of usage."

The need for a planned reliability program developed as:

1. Product complexity increased.
2. Lead time diminished.
3. Customers demanded better performance and service at reduced costs. The reliability group should:
 1. Establish reliability goals.
 2. Review product design from a reliability standpoint.
 3. Take corrective action.
 4. Establish controls on the manufacturing process.
 5. Maintain reliability as the product is used.
 6. Provide feedback of data to design and manufacture.

Organization for reliability must be such that it evaluates all areas of design, manufacture, and service. This can be accomplished by having the Director of Reliability as a member of top management.

To build reliable products, strict adherence to specifications must be accomplished. It is important that the complete desires of the design engineer be spelled out in specifications, including reliability requirements, so that when these specifications are met in manufacture the desired reliability is obtained.

In looking at the cost factors of reliability, they may be placed in these categories: failure costs, appraisal costs, and prevention costs. By reviewing these expenses, with the thought of reducing failure cost and building a reliability program around the appraisal and prevention areas, it becomes feasible that an effective reliability organization can be had without added cost, and, in most cases, with a savings. The objective is not to indicate the exact relationship of these three expenses, but to prompt analysis of one in view of the other. The ultimate goal is a balanced reliability organization and activity, enhancing quality with a continuous cost reduction in all three categories over the years.

Manufacturing controls can be established to measure the quality levels as parts are produced, to insure that maximum reliability is maintained.

This can be achieved with the establishment of rating factors which will indicate when a change in the manufacturing process has affected the quality, so that corrective action can be taken.

It is imperative for the Field Service Department to provide proper training and equipment to maintain reliability during the product's use, including consumer training. To improve failure data from the field, several auto makers have instituted a dealer sampling plan. This facilitates transmission of accurate information on product field performance to the reliability group. Under this plan certain dealers are selected throughout the country to obtain complete failure data as to the part that failed, mileage, body style, options, and so forth. This more accurate information will give the engineer a better understanding of his actual reliability so that positive corrective action can be taken. If failures do occur, the service organization must not only be able to efficiently correct the difficulty to the satisfaction of the customer but must also provide a feedback system so that information gets to the engineering and manufacturing groups. It must be accepted that the only real proof of reliability is the performance of the vehicle in the customer's hands.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: chairman E. S. Wellock, Chevrolet; J. F. Blamy, Pontiac; J. D. Bolles, Delco-Remy; E. D. Solms, Cadillac; J. R. Gretsinger, Buick; J. Knowles, Ford; and C. G. Bauer, Chrysler.

2 Fuel Properties Rate S.I. Resistance of Fuels

Based on paper by

J. A. ROBISON, R. G. MOSHER,
and W. K. OJALA

Ford Motor Co.

TWO fuel characteristics determine the relative resistances of fuels to surface ignition:

- Hot-spot ignition resistance, which is controlled solely by the temperature required to ignite the fuel mixture.
- Deposit ignition resistance, which is controlled solely by the surface heating ability of the fuel.

Neither of these fuel characteristics is completely understood, and both present challenges to future fuel research.

The temperature behavior of a combustible pellet provided the means of describing the difference in the hot-spot and deposit ignition mechanisms.

For hot-spot ignition of the mixture to occur, the hot-spot temperature must equal or surpass the ignition temperature required by the mixture. The hot spot does not necessarily burn, but may merely absorb heat and retain it from cycle to the next.

For deposit ignition of the mixture to occur, the deposit must first be "triggered" into burning. As it burns, its temperature rises unabated through the four strokes of the engine cycle—cycle after cycle—until it reaches its peak pressure. The rate at which it burns and its ultimate peak temperature will depend on several factors, including the temperature impressed on it and the amount of combustible material and oxygen available. If the deposit temperature equals or surpasses the ignition temperature required by the mixture, deposit ignition of the mixture will occur.

■ **To Order Paper No. 293D . . .**
from which material for this article was drawn, see p. 6.

All That Paper Work Isn't Really Necessary

Based on report by secretary

E. C. ANSON
CMC

PAPER WORK can be reduced considerably in all areas of business by report elimination, integration of data, exception method of reporting, cutting down on duplicate records, using one form to serve multiple purposes, improved data processing facilities. A constant awareness of the paper work problem must be developed, recognizing that each person who asks for information tends to generate paper work, and therefore shares the responsibility of determining its necessity and the degree of accuracy required.

Elimination of reports and integration of data are two important areas in reducing paper work. In one company, for example, engineering stock lists were, at one time, maintained and distributed by the engineering department to all areas. A blueprint machine was used to reproduce the required copies from a master sheet.

When product costs were mechanized on data processing facilities, the result was a mechanically prepared coded engineering stock list. This was a punched card record of engineering stock list information which permitted elimination of complete stock lists in all areas except the cost department. All other former users of the engineering stock lists now operate strictly from the engineering blueprints. The cost savings have been substantial.

Another dollar and time saver is the exception method of reporting—showing only the important off-standard data. Consider the preparation of material requirements purchase requisitions in one company. The material control department has established a percentage change factor in relation to the total schedule for each purchased and raw material item. As changes are processed by a computer, the requirements resulting from the change are checked against the percentage factor. Information is printed out to advise the material control department of the materials to be purchased only on those items where the change exceeds the percent allowance.

A bulletin board 68 ft long and 8 ft high was placed in the conference room by one plant to which were tacked copies of all of the stocked forms. All members of supervision were called in to make a complete analysis of the forms used. Recommendations were made to eliminate—combine—reduce—or simplify. Results were shocking with a 15% annual savings being made.

With increased computing and processing speeds, new and valuable information can be made available for the first time. Much of this information will pay its way and should be processed. The critical challenge, however, will be to guard constantly against the danger of the machine, or system, ruling the man.

There will be a strong temptation to ask for more and more data, just because it seems easy to get. This tendency could readily destroy much of the advantage of the new style facilities.

Based on report of discussion at panel on How Much Paper Work is Really Necessary?—R. M. Wagner, Chairman.

Aluminum Parts Reach New High on '61 Models

Based on report to

SAE Engineering Materials Activity
Committee by

MAHLON E. WOOD
Reynolds Metals Co.

MORE AUTOMOTIVE PARTS are being made of aluminum than ever before. Sand, permanent mold, and semi-permanent mold castings are finding greater application. So are pressure die castings for functional parts; also bright trim parts; impact extruded parts for high volume applications; hot extruded items such as grilles and window frames; also forgings for highly stressed functional parts.

Outstanding among new aluminum

developments on the 1961 models are the cast aluminum engines and components for the Corvair, Rambler, Olds F-85, and Buick Special.

For 1961 the Corvair powerplant is a refinement of the 1960 version, retaining the permanent mold cast crankcase and finned cylinder heads. The permanent mold and die cast aluminum components used by Corvair illustrate good design practice and demonstrate the ability of designers to combine several functional parts into a single component. This is especially true of a rear end cover die casting.

The die cast Rambler block represents a new approach to the passenger car powerplant. American Motors, in combination with Doehler-Jarvis, has designed its new 6-cyl engine for high production, using the die casting process. A binary aluminum-silicon alloy is specified. The block is cast integrally with pre-cast iron cylinder liners, thereby eliminating additional assembly operations. Many machining operations are eliminated by die casting rather than sand or semi-permanent mold casting.

The Oldsmobile F-85 and Buick Special V-8 blocks are semi-permanent mold castings having pre-cast iron liners cast integral with the block. Cylinder heads and intake manifolds, made by the same process, contribute to overall weight reduction. Buick reports total weight of the Special V-8 powerplant is only 318 lb.

New automatic transmission components are being made both as die-castings and as permanent mold castings. Versatility of design and manufacturing is demonstrated by many of the complex castings. Innovations include two aluminum castings welded into a single component.

The increased popularity of anodized trim parts made from sheet and extrusions reflects the metallurgical advances made by the aluminum industry in the last two years, providing more brightness on trim even when thicker anodic coatings are specified. New applications include the Chevrolet body side moldings. Aluminum grilles are being used on 20 of the 1961 models.

Navy Probes New Power Sources

Based on paper by

J. T. HAYWARD

U. S. Navy

FOUR energy conversion processes — thermoelectric, thermionic emission, chemical in fuel cells, and magnetohydrodynamic — are being investigated by the Navy in its search for compact, quiet, and economical power systems

for flight vehicles, remote and untended devices, and for shipboard.

While costs are still excessive, the outlook is favorable for using thermoelectricity for various refrigeration requirements on submarines. Silent operation and reduced maintenance, coupled with economical use of space appear to outweigh the penalty of added power consumption.

Three companies are working to develop a 500-w portable power pack for marine field use. Specifications call for weight not to exceed 35 lb and size to be no larger than 1 cu ft. Thermoelectricity is also being applied for coast guard buoy lights. A propane-powered, thermoelectric unit under construction is to have a 5-w output for three years on 400 gal of propane. Total cost is estimated at \$1.60/kw-hr compared to \$10/kw-hr for the present lead acid batteries, without including possible savings in servicing. Five small isotope-powered thermoelectric units have been requested from the AEC for various coast guard and remote weather stations.

A 5-kw oil-fired generator is now on test at Annapolis. To date the overall performance is disappointing, but the deficiencies can be overcome. The Bureau of Weapons is investigating the feasibility of a waste heat thermoelectric generator for aircraft power supplies. And the Office of Naval Research is investigating the use of nuclear, thermoelectric, multimegawatt power supply for Artemis, a large remote underwater acoustic device.

Indications are that the thermionic diode will become a serious contender for 5-day manned space missions. In pile, thermionic diodes offer a topping unit in conjunction with another converter such as thermoelectrics, and the diode offers the attractive feature of an exponential increase in power with increasing temperature.

Varied Types of Fuel Cells

The Bureau of Ships is procuring a large prototype low-temperature, hydrogen-oxygen cell, a sodium amalgam-oxygen cell, a 200-w membrane cell, and is supporting a modest effort on hydrocarbon cells. The Bureau of Weapons is supporting the development of a high-temperature-pressure hydrox cell, designed for appreciably higher output with respect to weight and size.

Magnetohydrodynamics

A program is underway on hot, efficient, conductive gas generation coupled with a program to extract electrical energy. This is backed by a high-temperature materials program, pursued for this and other military reasons.

■ To Order Paper No. 297B . . . from which material for this article was drawn, see p. 6.

New Truck Brake Is Oil-Cooled Unit

Based on paper by

D. A. GOTSCH

Auto Specialties Mfg. Co.

RECENTLY designed, the Ausco truck brake is an oil-cooled, multiple disc unit. It is completely sealed and full of cooling oil, which is in contact with the friction surfaces.

The brake cooling system consists of a positive-displacement oil pump, heat exchanger, reservoir, full-flow oil filter, and the necessary plumbing. (Fig. 1) The pump can be driven either by the engine or through the transmission

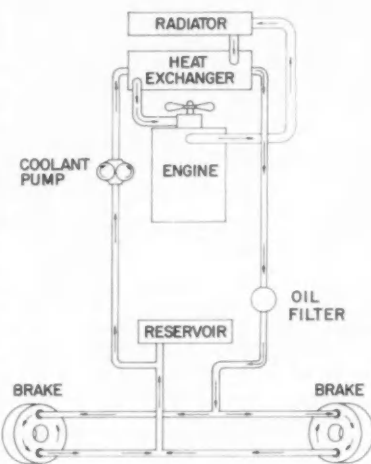


Fig. 1 — Cooling system for oil-cooled truck brake.

power takeoff or drive line. There is a total of 6 gal of transmission Type A oil in the system, including one-gallon in the reservoir.

Hot oil flows from the brakes to the suction side of the pump. It is pumped through the heat-exchanger back to the brake inlet. The heat exchanger is connected into the radiator bottom tank. So, the coolest water flows through the exchanger and back to the engine block. The oil reservoir is the highest point in the system, and maintains a slight pressure head to insure complete filling and exclusion of air.

A thermostatically-controlled bypass valve can be connected to the pump circuit, so that cooling oil is circulated through the system only when needed — at a pre-set oil temperature.

■ To Order Paper No. 304A . . . from which material for this article was drawn, see p. 6.

SAE NEWS



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A report from the BOARD OF DIRECTORS

At the April 7, 1961, meeting of the Board of Directors, the following actions were taken:

APPROVED

Hillyer College, University of Hartford, and Royal Military College of Canada for **SAE STUDENT ENROLLMENT** (Summary 3).

Election to **SAE MEMBERSHIP** of 91 applicants (Summary 4).

TRANSFER IN GRADE of five members (Summary 4).

COMMITTEE APPOINTMENTS (Summary 2) . . .

J. T. Dymont as SAE Representative on Guggenheim Board of Award.

Frank W. Fink on Board of Directors' Executive Committee.

Alexander T. Burton and Milton J. Kittler as members of Finance Committee.

E. J. Manganiello as SAE Representative and Joseph Gilbert as alternate on Intersociety Committee on Aerospace Meetings.

Expenditure of \$150 for distribution of program for **INTERNATIONAL HEAT TRANSFER CONFERENCE** (Summary 4).

CONFIRMED

Affirmative action taken on ballot on amendments to **ASA BY-LAWS** (Summary 2).

Executive Committee action approving that **NONMEMBER REGISTRATION FEES FOR ENGINEERING DISPLAYS** be made flexible (Summary 1).

REJECTED

Proposal by **SAE MEMBER HENRY H. WAKELAND** (Summary 5).

Invitation to participate in **FUTURE SCIENTISTS OF AMERICA AWARDS** program (Summary 6).

Ten applicants for **MEMBERSHIP** (Summary 4).

①

Nonmember Registration Fees Made Flexible at Engineering Displays

At its meeting on September 20, 1960, the Directors had fixed a nonmember registration fee of \$1.00 for all SAE engineering displays. Since that time the Engineering Activity Board recommended that it be authorized by the Directors to make the determination of the nonmember registration fee at each engineering display. The Engineering Activity Board pointed out that circumstances vary at each national meeting and engineering display and that a more flexible policy on nonmember

registration fees appeared to be in order.

The Board of Directors confirmed its Executive Committee action charging the Engineering Activity Board with the responsibility of determining whether a nonmember registration fee should be charged and of setting the fee at each SAE engineering display.

②

Presidential Appointments

The Directors confirmed President Kucher's appointment of the following:

- (a) **J. T. Dymont** as an SAE representative on the Daniel Guggenheim Medal Board of Award for a term of three years, beginning October 1, 1961.
- (b) **Frank W. Fink** as a member on the Board of Directors' Executive Committee for 1961.
- (c) **Alexander T. Burton** and **Milton J. Kittler** as members of the SAE Fi-

nance Committee for 1961. (These appointments grow out of a recent amendment to the By-Laws approved by the Directors to increase the number of appointed members on the Finance Committee from four to six.)

- (d) **E. J. Manganiello** as SAE representative and **Joseph Gilbert** as alternate on a special intersociety committee consisting of representatives from the American Society of Mechanical Engineers, Institute of the Aerospace Sciences, American Rocket Society and SAE. Purpose of the group: to coordinate national meetings in the flight sciences field.

The Directors also confirmed President Kucher's affirmative ballot, on behalf of SAE as a member body, on amendments to the American Standards Association Constitution and By-Laws to:

1. Enlarge ASA's Board of Directors to provide for greater representation from all classes of members;
2. Enlarge the officers structure (VP's) in order to assign them specific duties.

"A summary report of the actions of the Board of Directors shall be published in the next following issue of the official publication of the Society." . . . From C 6 of the SAE Constitution.

3

Two Schools Added to SAE Approved List

At the recommendation of the Membership Grading Committee, the Directors agreed to the addition of the following schools to the list of those from which SAE may accept students as SAE Enrolled Students and, graduation from which may be considered a qualification for election to Junior grade of membership:

- Hillier College, University of Hartford, Hartford, Conn.
- Royal Military College of Canada, Kingston, Ontario, Canada

4

Other Board of Directors' Actions

The Directors acted favorably on 91 applications for membership, approved the transfer of Grade of 5 members and denied membership to 10 applicants.

The Directors heard a report on plans for the program for the 1961 International Heat Transfer Conference and approved of an expenditure of up to \$150 for distribution of the program for this meeting.

5

Proposal by SAE Member Henry H. Wakeland

The Directors unanimously voted to reject the proposal submitted to them several months ago by SAE Member Henry H. Wakeland that the following resolution be adopted by the Society:

Be it resolved:

WHEREAS, the Society of Automotive Engineers has as one of its purposes "to promote . . . Standards . . ." in connection with the design, construction and utilization of automotive apparatus,

THEREFORE, the Society opposes, in general, the application of its stand-

ards in ways that would tend to limit or preclude the growth of other standards which may be advanced by other groups and which have not been published by the Society.

Mr. Wakeland's proposal was based on a revision to a proposed Congressional bill submitted by the Automobile Manufacturers Association. The bill, H. R. 1341, concerns itself with the purchase of passenger vehicles by the Federal Government. The section of the AMA proposed revision of H. R. 1341 which generated Mr. Wakeland's six-page presentation to the Directors reads as follows:

"Sec. 2 The Secretary of Commerce shall prescribe and publish in the Federal Register ~~commercial~~ standards for such safety devices as he may require under authority of the first section of this Act. Such standards shall conform to nationally recognized standards such as those published by the American Standards Association and the Society of Automotive Engineers. The standards first established under this section shall be prescribed and published not later than one year from the date of enactment of this Act, and be revised from time to time to conform to revisions in said nationally recognized standards." (Underlined sections were added by the Automobile Manufacturers Association and lined through words were struck out.)

After a careful appraisal and review of the Wakeland documentation, the Directors saw no need for adopting the resolution he proposed. The Board's reasoning for its action can be summarized as follows:

1. In his presentation, Wakeland implied that the proposed revision of H. R. 1341 urged Federal use of SAE standards to the exclusion of all others. The proposed revision calls for conformity to nationally recognized standards "such as those published by the American Standards Association and the Society of Automotive Engineers." The statement *does not* state that the standards of SAE should be used to the exclusion of all others. Further, it mentions the American Standards Association. In the third place, it does say that standards "shall conform to nationally recognized standards such as those . . ."

In other words, the ASA and SAE are mentioned in this context merely as examples of nationally recognized standards-making bodies to whose standards the federal requirements should conform.

2. The resolution proposed by Mr. Wakeland is completely out of character in SAE. That is because the Society has always felt that there is room as well as need for the work of other organizations in the standardization field. As a matter of fact, SAE is a member body of the American Standards Association and co-operates closely with other standardizing groups such as ASTM, ASME and the Society of Plastics Industry. Acceptance by the Board of Directors of the resolution proposed by Mr. Wakeland would imply that this may be a new stance within the Society—which, of course, is not the case.

3. If Mr. Wakeland proposes duplication in the standards area, he is both unrealistic and impractical. Here's why:

a. SAE, or any other standards-making body, is performing its job because it believes itself to be the most competent group in its specific field.

b. To invite another group to "come and standardize in our field" just about says that "maybe you can do a better job than we can."

c. Duplication of the kind inferred by Mr. Wakeland is just the kind of waste of engineering manpower, time and money we are seeking to eliminate. The conservation of engineering effort is an aim of the profession itself, industry management and government agencies and officials.

d. To promote a wide-open field on standards would dilute the talent available to any single group so that the quality level of the "standards product" would have to be lower than if one organization is doing the job.

4. It has been the Society's philosophy and principle of operation that SAE standards are completely voluntary. There is no compulsion on anyone's part to use them. They are issued as being representative of sound and current engineering practice.

5. The criticism of the slowness of SAE procedures quoted in a reference in the Wakeland presentation is an unfair and undocumented charge. As a case in point, SAE was the first organization to develop a specification for motor vehicle seat belts. The SAE document has been adopted in the main by a number of states.

Mr. Wakeland was advised of the Board of Directors' action by way of

the following letter to him from SAE President Kucher.

Dear Mr. Wakeland:

This is to advise you that the SAE Board of Directors has given careful consideration to your recommendation of January 2, 1961, and your letter of January 28, 1961. Although the Board appreciates your interest in the Society which prompted you to propose the resolution submitted, it does not agree with your premise or the conclusions growing out of your reasoning. Therefore, the Directors have asked me to advise you that they were unanimously opposed to your proposed resolution.

It is the Directors' considered judgment that an organization is known by its accomplishments, objectives and behavior—not by its own proclamations on the merit and value of its work. SAE Standards and Specifications, and their usefulness over the years, speak for the Society's work in this area.

There are two related facts which I would like to call to your attention. The first is the statement under the SAE Technical Board Rules and Regulations, which says that:

"2. Responsibilities and Qualifications of Members — In discharging their responsibilities, members of the Technical Board, its Councils and committees function independently as individuals, and not as agents or representatives of the organizations by which they are or may be employed. Members shall be appointed on the basis of their personal qualifications and consequent ability to contribute to the work of such groups. Invitations to serve as members shall call attention to this Section of the Rules."

The second item is also from these Rules and Regulations. It reads as follows:

"8.3 Every approved report shall carry the following statement: 'All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE Standard or SAE Recommended Practice, and no commitment to conform to or be guided by any technical report. Etc., etc.'"

The Society has always adhered to these principles . . . in both intent as well as practice. The Directors feel that our technical committees have been carrying out their technical mission most effectively and are to be commended for it. For the Society to become enmeshed

in political or commercial involvements in areas related to our technical work would be out of character and outside of the SAE province, as circumscribed by our Charter and Constitution.

Sincerely,

A. A. Kucher, President

The Directors also instructed that copies of President Kucher's letter to Mr. Wakeland be distributed to the Chairmen of the Governing Boards of SAE Sections and Groups, since Mr. Wakeland had previously sent copies of his proposal to these people.

6 SAE Declines Participation in Future Scientists of America Awards

The Directors voted to decline the invitation to SAE to join with other engineering and scientific societies in cosponsoring the National Future Scientists of America Awards program. Sponsorship in this program entails a contribution of \$1,000 per year to support it actively and assistance in selecting members to judge student entries in the program.

Basis for the declination is that such participation would be contrary to SAE Constitutional objectives. Paragraph C 2 of the Constitution states that "The object of the Society is to promote the Arts, Sciences, Standards and Engineering Practices connected with the design, construction and utilization of self-propelled mechanisms, prime movers, components thereof, and related equipment." According to paragraph C 3, the principal means for accomplishing the object in C 2 is through meetings at which technical papers are presented and through the development of publications of technical reports and engineering standards.

B 1 of the By-Laws points out: "In the other areas permitted under C 2 of the Constitution efforts of the Society shall be limited to those activities in its technical areas which contribute to individual member service and enhance the value of Society membership to the individual member."

Since participation in the Future Scientists of America Awards program would not conform with the Society's main reason of being and since it would not "contribute to individual member service and enhance the value of Society membership to the individual member," the Directors reasoned that SAE participation would be a violation of its Constitution and By-Laws if the invitation were accepted.

Job Listings for Students

THE STUDENT LISTINGS FOR PERMANENT POSITIONS have not yet run their course. Therefore, we do not know what the final results will be. We have hopes that they will come closer to matching last year's record before the time runs out. Then, 87% of the Students received at least one inquiry.

To date, the record is as follows. This year, 255 Students sent us their brief write-ups for permanent positions. Of these, 183 have received inquiries ranging all the way from one inquiry up to eight.

Our biggest problem, however, continues to be summer employment. Of the 160 that requested it, only 15 have had any inquiries at all.

This problem is uppermost in the minds of the members of the Placement Committee who recognize this as a local problem because, in the main, the Students desire summer jobs near home. Furthermore, the Placement Committee is endeavoring to expand this effort and hopes that a way will be found to give better service to this group.

Burton and Kittler Named to SAE Finance Committee

SAE FINANCE COMMITTEE, beginning this year, has seven members — instead of five as in the past. In addition to reappointment for 1961 of the five members who have served for some years past, President A. A. Kucher has appointed two new members to fill the additional places on the Committee:

The two new members are Alexander T. Burton, vice-president, North American Aviation, Inc. and Milton J. Kittler, executive vice president, Holly Carburetor Co. In the accompanying picture they are shown with Finance Committee Chairman A. T. Colwell, director, Thompson Ramo Wooldridge, Inc.

Reappointed to the Finance Committee, in addition to Chairman Colwell, are: B. B. Bachman, Autocar Division, White Motor Co.; George A. Delaney, SAE treasurer; Walter F. Rockwell, chairman, finance committee, Rockwell Manufacturing Co.; and James C. Zeder.



FINANCE COMMITTEE CHAIRMAN A. T. Colwell (left) chats with two new members of the Finance Committee, Alexander T. Burton (center) and Milton J. Kittler (right).

THE 1960 HORNING MEMORIAL MEDAL goes to W. G. Agnew, General Motors Research Laboratories' senior engineer, for his 1960 Summer Meeting paper "End-Gas Temperature Measurements by a Two-Wavelength Infrared Radiation Method." A story based on the paper appeared in October, 1960 SAE Journal (pp. 62-67) . . . and the complete paper will be published in 1961 SAE Transactions.

Presentation of the award to Dr. Agnew is scheduled for the 2:00 p.m., 1961 Summer Meeting session on June 8 in the Chase-Park Plaza Hotel, St. Louis, where plans call for participation of C. M. Heinen, 1960 Horning Board of Award chairman, and Mrs. Elsie M. Horning, sponsor.

Agnew received his B.S., M.S., and Ph.D. degrees in mechanical engineering from Purdue University. Prior to joining General Motors Research Laboratories in 1952, he served the U. S. Army in Manhattan District Corps of Engineers, Los Alamos Laboratory, where for six months after Army discharge he continued research on high



W. G. Agnew

Is 1960

Horning Memorial

Medalist

explosives. He became an SAE member in 1953.

In 1957 at GM Research Laboratories, Dr. Agnew was appointed research associate in the Fuels and Lubricants Department. His work there has included studies of the effects of atmospheric conditions on engine performance; formation of induction system deposits; radiant energy and radi-

ation temperature measurement in gas turbine combustors; end-gas temperature measurement in spark ignition engines; preflame reactions and cool flames; and engine knock and anti-knock mechanisms.

Serving with Chairman C. M. Heinen on the 1960 Horning Board of Award which selected Agnew as medalist, were C. E. Cummings and W. S. James.

SAE Sections Area Coordinators Register One Year



ACHIEVEMENTS OF THE AREA COORDINATOR PROGRAM during its first year of operation have more than lived up to expectations . . . Sections Board Chairman Paul F. Allmendinger reported recently.

Many activities and procedures found useful in one Section have been passed on to others through this program. Section and student questions



J. H. Overwein

have come to light for guiding answers and solutions . . . and explanations of new SAE procedures and policies have been brought to Section Governing Boards first hand through individual,

periodic visits of members of this 15-man group.

Two "Area Coordinator News Letters" have been issued out of the three-year schedule at the outset of the program. A third, editor J. H. Overwein reports, is in the making. These News Letters have been serving a dual purpose, in that they provide means for passing on the after-Section-visit reports of the coordinators to all concerned . . . and because any unresolved problems automatically provide a ready-made agenda for discussion at Area Coordinator meetings.

Among the more recurring problems discussed by Section Governing Board members with their visiting Coordinators have been:

- Setting Section membership goals and how to attain them.
- Social hours—and how best to handle.
- How useful is the printed Section Roster?
- Handling of Section-sponsored student awards.
- The rejected membership application.
- Section finances.

Area Coordinators

New England, Southern New England

R. K. BLAKESLEE

American Bosch Div., American Bosch Arma Corp.
Springfield, Mass.

Chicago, Fort Wayne, Rockford-Beloit

P. F. ALLMENDINGER

Stewart-Warner Corp.
Chicago, Ill.

Cleveland, Pittsburgh, Buffalo

A. D. GILCHRIST

Leece-Neville Co.
Cleveland, Ohio

Metropolitan, Syracuse, Mohawk-Hudson

R. W. HOGAN

Ethyl Corp.
New York, N. Y.

Kansas City, Wichita, Mid-Continent, Colorado

M. F. KENT

Garrett Corp.
Wichita, Kans.

Philadelphia, Williamsport

G. J. LIDDELL

Sun Oil Co.,
Marcus Hook, Pa.

Central Illinois, St. Louis

W. H. McGLADE

LeTourneau-Westinghouse Co.
Peoria, Ill.



C. A. DILLINGER (left), general chairman of the 1961 National West Coast Meeting to be held in Portland, Ore., Aug. 14-17, receives some pointers from **I. M. HARLOW** (right) who was general chairman of the 1960 National West Coast Meeting held last August in San Francisco. Dillinger heads Tokheim Pump Agency, Portland, Ore., and Harlow is research supervisor for Tidewater Oil Co., Martinez, Calif. **E. W. RENTZ, JR.** (center), SAE's Western Branch Office manager, looks on.

of Progress

San Diego, Southern California, Salt Lake, Northern California, Hawaii
I. M. HARLOW
Tidewater Oil Co.
Associated, Calif.

Milwaukee, Twin City
F. B. ESTY
Wisconsin Motor Corp.
Milwaukee, Wisconsin

Ontario, Montreal
A. L. GRAY
Gray Forgings & Stampings, Ltd.
Toronto, Ont., Canada

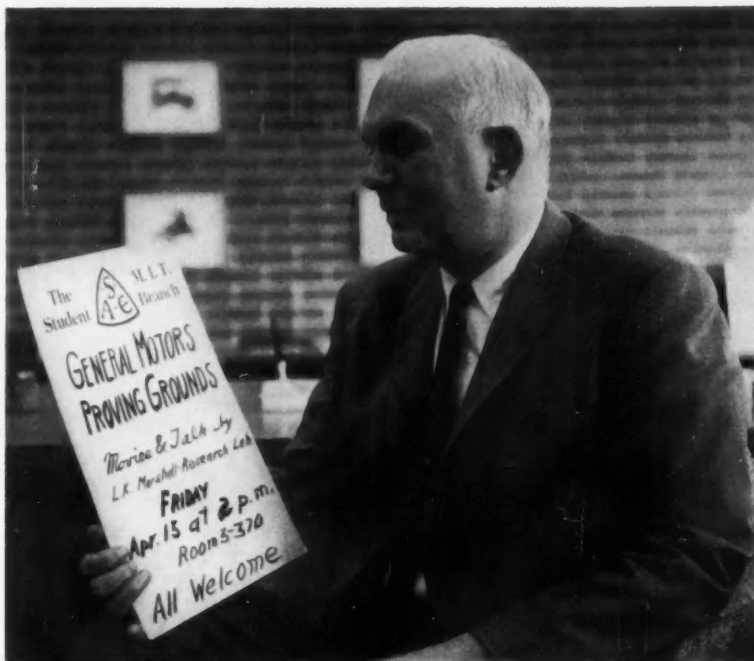
Baltimore, Washington, Virginia, Atlanta
L. C. KIBBEE
American Trucking Associations, Inc.
Washington, D. C.

Oregon, Northwest, Spokane-Intermountain, British Columbia, Alberta
C. A. DILLINGER
Tokheim Pump Agency
Portland, Ore.

Cincinnati, Indiana, Dayton
J. H. OVERWEIN
Inland Mfg. Div., GMC
Dayton, Ohio

Detroit, Mid-Michigan, Western Michigan
BERNARD E. RICKS
Thompson Prod., Mich. Div.
Thompson Ramo Wooldridge, Inc.
Warren, Mich.

Texas, Texas Gulf Coast, South Texas
H. P. LIVINGSTON
Humble Oil & Refining Co., Humble Div.
Dallas, Tex.



ARTHUR J. UNDERWOOD, manager of GM Research Laboratories, holds the announcement of an MIT Student Branch meeting at which he presided as Student Branch Chairman 33 years ago. At the meeting, he got acquainted with the speaker (L. K. Marshall of GM's Research Laboratories). . . . Result: He went to work at the GM Research Center upon graduation from MIT a few months later. . . .

Not only did SAE activity result in his getting this first job, but "it has served as an introduction to many satisfying accomplishments in my business and social contacts," Underwood

told a group of SAEers recently. "SAE rounded out my engineering career," he says, "in many ways." Through SAE, he says he has: met leading engineers in his own and affiliated fields; become better known to his colleagues; gained a wider engineering interest through local and national meetings; come into contact with engineers of his own and other companies—become better known to these men; gained real satisfaction from the fact that in paying his own dues to SAE he is paying his own way in this phase of his career as an engineer. He became a member of SAE in 1930.

Vickers Reports on Heat Transfer Conference

PAUL T. VICKERS, SAE representative, has played an active part in development of the program for the Second International Heat Transfer Conference scheduled to start Aug. 28 at the University of Colorado.

Vickers, who is supervisor of the heat transfer section of the gas turbine department of GM Research Laboratories, was named SAE representative to the Conference by the SAE Board of Directors. He reports that the program developed is well oriented to interest a wide range of SAE members.

Reporting to the Directors at their April meeting, Vickers said that new material originating during the 10 years since the first IHT Conference will be presented at this second Conference. There will be 125 papers from 13 different technical societies and at least 12 different countries.



Paul T.
Vickers

"As our technology has developed" Vickers pointed out, "particularly in the aerospace field, heat transfer phenomena have become increasingly important. Due to the very nature of the materials problems, some heat transfer analysis during the design and development of mechanisms often means the difference between success and failure of a venture.

"Until recently, SAE had not devel-

oped a need for concentrated effort in this field, principally because designers of spark-ignition reciprocating engines have developed a 'feel' for their cooling problems which far surpasses all the analytical treatments possible. But in such fields as gas turbines, aerospace, air-cooled engines, automotive air conditioning systems, and turbo-charged engines heat transfer techniques are being used extensively on some of the really tough materials and developmental problems.

"Four times as many papers were rejected for this Conference as were accepted. Important among those accepted is one by SAE Member J. R. Mondt on 'Effects of Longitudinal Thermal Conduction in the Solid on Apparent Convection Behavior, with Data for Plate-Fin Surfaces.' This paper sheds new light on anomalous behavior of heat-changer surface performance which has plagued industry for many years."



MID-CONTINENT SECTION Chairman Walter J. Ewbank (left) presents 25-yr SAE membership certificate to Garland C. Richardson, (right) Cities Service Oil Co.'s general manager, Supply and Service Division.

Rambling through the Sections

THE TORQUE CURVE of the Olds F85 aluminum engine was determined by computer. . . . The block is a semipermanent mold casting of 356 alloy, and the heads are of the same material. These and other facts about this engine were contained in the talk by Frank W. Ball, Jr., of GMC's Olds Division, before the March meeting of **INDIANA SECTION**. (A story based on Ball's talk will appear in a forthcoming issue.)

OREGON STATE COLLEGE STUDENT BRANCH won \$125 last year as first prize for the skit it put on during the College's "Engineer's Bust" . . . and has just awarded the prize money as a scholarship to Senior Branchmember David H. Payn. The recipient for the scholarship award was chosen by Branch Faculty Advisor Professor W. H. Paul, Professor Louis Slegel and Branch Chairman Ron Householder. Criteria were: grades, college activity, and need. Professor Paul is also **OREGON SECTION** vice-chairman for student activity.



John K. Krestan (left) receives from **BUFFALO SECTION** Chairman John F. Murphy a plaque in recognition of his 25 years of SAE membership.

TEN NOTRE DAME ENGINEERING STUDENTS were introduced by faculty member Dr. F. H. Raven to 75 members and guests at **CHICAGO SECTION'S SOUTH BEND DIVISION** meeting . . . where they heard TWA's Director of Engineering, C. A. Fisher talk on "Technical Service at the Jet Pace."

Cited among accomplishments since the first commercial jet flight in March 1959, were:

- 250 jets now operating to 276 cities average one departure per minute.
- Daily flights are equivalent to 63 trips around the world.
- One jet equals three Constellations or DC 3's.
- 17% of all aircrafts are jets . . . but they carry 50% of the traffic.
- Where mechanical delays accounted for 13% at the start, the jet figure is now 6% — only a bit higher than that for piston engine craft.
- The \$30,000 ground equipment engine starting car is apt to give more trouble than the \$5,000,000 jet.



AT **CHICAGO SECTION'S SOUTH BEND DIVISION** meeting on March 20 — 2nd anniversary of the first commercial U. S. jet flight — (top picture, left to right) are TWA's Director of Engineering, Clark A. Fisher (speaker); Stanley B. Smith, Bendix assistant director of engineering; E. L. Moyer, Bendix chief engineer for wheel and brakes; Dr. F. H. Raven, Notre Dame faculty advisor.

(Bottom picture, left to right) T. H. Thomas, Bendix assistant manager automotive section; W. A. Gebhardt, Bendix management staff, and Chicago Section past chairman; E. D. Hendrickson, Hendrickson Mfg. Co., and Chicago Section chairman; W. R. Williams, Bendix assistant chief engineer, vacuum power, and vice-chairman Chicago-South Bend Division; G. E. Stanton, Jr., Bendix chief project engineer and technical chairman of the meeting.



Standing together (starting left), NORTHERN CALIFORNIA SECTION Student Vice-Chairman Forest W. Fingerle and Section Chairman Irving M. Harlow view with others the M-113 vehicle differential on a tour of Food Machinery & Chemical Corp.'s San Jose Ordnance Division plant. At extreme right is K. Keoupplemaki of Lockheed's Missiles Division.

JUST ONE MONTH after the first M-113 vehicle rolled off the track, 85 SOUTH BAY DIVISION (NORTHERN CALIFORNIA SECTION) members on March 7 toured the Food Machinery Ordnance Division plant at San Jose where the M-113 is produced. After the tour, they heard the company's chief engineer, P. S. Devirian, tell about development of this family of high-speed, amphibious, air-dropable, combat and missile support, tracked vehicles. (A story based on Devirian's talk will appear in a forthcoming issue.)



Group inspecting M-113's armor-plate aluminum hull structure at SOUTH BAY DIVISION (NORTHERN CALIFORNIA SECTION) March 7 tour of Food Machinery & Chemical Corp.'s Ordnance Division San Jose plant.



(Left to right) at MID-MICHIGAN SECTION'S "Father and Son Night" are Section Vice-Chairman Raymond J. Schultz; former racing champion and featured speaker Peter De Paola; and A. C. Spark Plug's Staff Engineer, Robert W. Smith.

MID-MICHIGAN SECTION "fathers and sons" participated in a tour of General Motors Institute at Flint on March 6 . . . and an "afterward" dinner session where they heard the former racing "great," Peter De Paola talk on "Indianapolis to Go-Karts." While auto racing in general, and the Memorial Day Classic in particular served in the past as proving ground for automobile development, nowadays, De Paola said, racing has become almost exclusively a sport . . . and he attributed this to the finer and more extensive proving ground facilities of the manufacturers.

ESCAPE VELOCITY OF A TRIP TO THE MOON from earth would be at 35,000 fps; from a space station, with less gravitational pull, at 25,000 fps. Space station maintenance would be by men wearing pressurized, protective clothing — orbiting with the station — or by a crew in small Remora capsules. BUFFALO SECTION at its March meeting heard Bell Aerospace Corp.'s project engineer, George B. Melrose, Jr., tell of the foregoing in his talk on the "Space Race."



At BUFFALO SECTION'S March meeting, Bell Aerospace Corp.'s George B. Melrose, Jr. (center) spoke on "The Space Race." Shown with him are Section Program Chairman Earl Lenz (left), and Section Chairman Robert E. Lenz (right).

Rambling through the Sections

... continued

DECISION to lease or not to lease automotive equipment should be based upon expected earnings of the funds released as compared to the cost of leasing . . . Shell Oil Co.'s P. G. Anderson told **GULF COAST SECTION** at its March meeting. And, since leasing is a financial matter, it should be considered separately from the services offered . . . which may be obtained without leasing. Timing of payments is important to the cost, he added, and as one criterion for best-leasing-plan selection he suggested the discounted-cash-flow method.



Shell Oil Co.'s Paul G. Anderson points to cost factors used to illustrate his paper on leasing at **TEXAS GULF COAST SECTION'S** March meeting. With him are (left) J. D. Little, the Sections transportation & maintenance vice-chairman, and (right) Leslie P. Graff, Section chairman. Anderson is also Section secretary.



EARTHMOVING EQUIPMENT was discussion topic at **HAWAII SECTION'S** March meeting, where (starting right) Ed. Smith, George W. Wallace, and Harry Pertz—all of Theo. H. Davies & Co.—were speakers. William J. Maze (extreme left) of the same company, sponsored the program.

HAWAII SECTION was host to SAE Past-President Ralph R. Teetor late in March. It welcomed at the same time John A. C. Warner, SAE Advisory Consultant, who had last visited the islands in 1953 as SAE Secretary and General Manager. Teetor was guest of honor at a Section luncheon, where both he and Warner spoke briefly —Teetor of some engineering aspects of the "speedostat" safety device which he has been developing for some years past; Warner of changes and progress which is going forward throughout the SAE.

Teetor and Warner were in Hawaii for several days on their way to Japan and other points in the Far East.

Articles

in this issue

based on

Section

presentations . . .

• Central Illinois Section—

Earthmoving Industry
Conference

Of course the Engineer Is
a Threat to Society p. 32

—E. J. Tangerman

• Chicago Section

How to Get Big Car Rid-
ing and Handling in a
Small Car p. 38

—G. W. Gibson

SAE LETTERS FROM READERS

From:

Henry H. Wakeland (M'48)
2 Tudor City Place
New York 17, N. Y.

Dear Editor:

The speech of Member John F. Gordon before the SAE Annual Banquet seems memorable both of its theme and style. As interpreted by SAE Journal (March, 1961) Member Gordon emphasized that the "... two most formidable challenges facing automotive engineers today" are "foreign competition" and "those who urge a new austerity."

How his choice of words must have thrilled the audience as he skillfully skewered those "... lay evangelists whose doctrine is ... that the American way of life is a sinful way" and who "almost seem to suffer from a guilt complex." And those effective rhetorical questions! "Isn't a mistake made by a bureaucrat affecting thousands more disastrous than one made by an individual affecting only himself?"

Excellent styling of words, and probably not many who heard the speech at that day and place would have disagreed with its message.

One mark of a learned profession is a tradition of critical comment and elevated argument within the profession. Suppose that some SAE member might seek to report after research whether the "lay evangelists" might possibly be competent scientists of some other profession, or what their own statements had been? Perhaps some member might even study in detail and report whether a "mistake made by a bureaucrat affecting thousands" might refer more often to government bureaucrats or industrial bureaucrats.

How might such members actually deliver professional rebuttal to a Banquet Speech? Could they write a paper for publication by SAE? Wouldn't all possible rebuttals of that speech be rightly regarded as "outside the purposes of the Society" or "commercial" and therefore unacceptable?

Speakers at the Annual Banquet are allowed full freedom to express themselves and their remarks may be published all over the country, as were those of Member Gordon. Except for the limited readership of a letter to the editor, no rebuttal seems possible within the Society. Political scientists call this "differential access to the public." The possessor of "differential access" can "tell 'em off" without fear of being "told right back." In the battle of ideas that is a very useful tool,

allowing much to be said that otherwise would not be said. Member Gordon was fully justified in using this opportunity to spread his views, as have other speakers at other Annual Banquets.

Nevertheless, Mr. Gordon appears to have exhorted his professional colleagues to accept two industrial sales problems as professional goals. Our SAE goal of advancement of the Arts and Sciences does not distinguish between advances made first here or abroad. Certainly if the critics are merely "lay evangelists" sales people could better explain to them the error of their ways than could professional engineers. Yet, as the Journal weighed the speech, the two problems were "the two most formidable challenges facing automotive engineers today."

To me, Member Gordon has over-emphasized the role of the engineer as "organization man." He has not only revealed a view of his own that professional engineering is primarily a means to the business organization's end; he has also endowed automotive engineers in general with these same primary goals. Our real aims are better than that.

What makes the difference between a professional society and a trade association? A Society's name and purposes may be on record, but all publications, papers, and speeches speak louder. There is a difference between material which advances the Arts and Sciences and material serving industrial self-interest. That difference must be clean-swept and distinct.

This concern is mere constitutional technicality. If we swallow the idea that commercial motivations are our true and primary motivations we forfeit the claim to professional detachment. And such a forfeiture would be felt first among those who fear "bureaucrats." In such fields as design safety, the claim that professional detachment and ethics are the primary basis for design decisions is the most important argument for persuading the public to refrain from regulation.

In recent years SAE has fostered specific programs for raising the professional quality of papers. This helps to resist commercialism and technical propaganda, since high professional quality drives these out. Still, SAE members individually must monitor their own words and must comment freely when necessary. The Board of Directors and Activities cannot do it all.

From:

E. A. Sammis (M'51)
New York, N. Y.

Dear Editor:

I have just read the account in the March 1961 SAE JOURNAL of the chief address by John F. Gordon at the International Banquet of the 1961

Congress and Exposition of Automotive Engineers.

The picture I get from the report is a frightening one. I am dismayed by an apparent sense of values which places before automotive engineers, as one of the two most formidable challenges they face today, "the challenge of those who urge a new austerity ... who urge that the American way of life is a sinful way." I am concerned with Mr. Gordon's seeming preoccupation with the defense of "material indulgence."

From:

W. F. Sherman (M'36)
Manager
Engineering & Technical Dept.
Automobile Manufacturers Association, Inc.
Detroit 2, Mich.

Dear Editor:

The coverage of the overseas participation in the National Meeting, with pictures, etc., in the March SAE Journal helps to emphasize the significance of this session and the values which are in it for SAE.

I think the Journal coverage of this session is unusually good.

Congratulations.

From:

Carl H. Boas (M'53)
President
Altem Engineering Co.
226 Friedensburg Road
Mt. Penn, Reading, Pa.

Dear Editor:

As a member of SAE, I am naturally interested in the monthly Journal. Some months ago (in 1960) I noticed the article regarding noise attenuation in jet type aircraft.

I am president and chief engineer of Altem Engineering Co., which does consulting work for various aircraft companies in the general area. We were recently commissioned to design a bark suppressor for the inboard exhaust ports on R-2800 engines on a Martin 404.

By utilizing the ram-air input—in two sizes, plus a special device for obtaining from the mixture a subharmonic resonance effect, we have been able to reduce takeoff sound level from 111 db to 104 db, and general flight (cruise) level from 93 db to 88 db.

This is the first time, I believe, that a "muffler" has been added to an aircraft piston type engine which caused NO change in any instrument readings; i.e., manifold pressure, head temperature, carburetor heat, oil temperature—where all power and prop settings stayed the same and caused such a remarkable drop in energy level.

I have always enjoyed reading SAE Journal, and being a member of the organization. ... Both are "tops."

SAE MEMBERS



Lewis

ROBERT P. LEWIS has retired as consultant to the vice-president of engineering of Dana Corp., the organization with which he had been associated since 1928. He plans to do consulting work on an independent basis and also some technical writing. His address is 2256 Densmore Drive, Toledo 6, Ohio.

Lewis — a member of SAE for 42 years — is a past member of the SAE Technical Board and has participated actively in many of the Board's technical committees. He was first chairman of the Transmission Committee and recently was made an honorary member of that group. He has also received a Certificate of Appreciation in recognition of his contributions. Also he has long been active in the Passenger Car Activity Committee and has served as chairman of its meetings committee.

Before entering the automotive field in 1928, he had been a designer for Glenn Curtiss and the Dayton Wright Co. . . . and during World War I had charge of a section of the Engineering Department of the U.S. Naval Aircraft factory in Philadelphia.

Lewis joined Dana's Salisbury Axle Division in 1928 and advanced to director of engineering for the Dana Corp. in 1954.

CARL F. JOSEPH, formerly technical director of Central Foundry Division of General Motors Corp. has joined Miller and Co. as consultant. Joseph retired from General Motors Corp. in November, 1960 after 43 years of service.

THEODORE P. WRIGHT has been elected president of the Flight Safety Foundation. Wright was formerly vice-president of research at Cornell University and has been Civil Aeronautics Administrator.

CARL A. KOERNER has been appointed divisional works manager for the Central Foundry Division, General Motors Corp. He was formerly divisional director of sales and engineering for GMC.

CHARLES E. DRURY has been named divisional director of sales and engineering for the Central Foundry Division. Formerly divisional director of reliability for GMC.

KENNETH L. HULSING has been appointed assistant director of engineering for Detroit Diesel. Hulsing was formerly staff engineer in charge of product design for Detroit Diesel.

ELMER E. BRAUN has been appointed general manager of the Central Foundry Division of General Motors Corp. Braun was formerly works manager of the division.

F. L. LAQUE, vice-president and manager of the Development and Research Division of The International Nickel Co., Inc., has been appointed as one of three representatives of the American Society for Testing Materials on the Standards Council of the American Standards Association for a term expiring in 1963.

EARL K. BROWNRIDGE has been elected president of American Motors (Canada) Ltd. Formerly he was executive vice-president and general manager.

M. F. BALDWIN, JR. has been appointed department manager — information processing at Lockheed Missiles & Space Division, Lockheed Aircraft Corp. Baldwin was formerly supervisor, data processing at Lockheed.



Joseph



Wright



Koerner



Drury

FRANK N. PRICE, JR., formerly senior project engineer, environmental control subsystems, headquarters, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio, has been appointed assistant chief, Mark I Aerospace Systems Environmental Simulator Project Office, Arnold Engineering Development Center, Arnold Air Force Station.

FRED O. HOSTERMAN has been named president and chief executive officer for Weston Hydraulics, Ltd. He was formerly president and general manager for the company.

Hosterman has served SAE in many capacities: Chairman, So. Calif. Section, 1950-51, General Chairman, National Aeronautics Meeting, October, 1954, Meetings Chairman, SAE Aircraft Activities Committee, 1955, Chairman, Technical Committee A-6A, 1948-57.

LEO W. TOBIN, JR. has been appointed executive assistant to the vice-president-manufacturing, Ford Motor Co. Tobin was formerly chief engineer of automotive products at the division's Flint, Mich. plant.

JAMES KNOWLES has been named quality control manager for Ford's Automotive Assembly Division.

JACK E. CHARIPAR, chief engineer and director of product of the Plymouth Division, Chrysler Corp., has been awarded an Alfred P. Sloan Fellowship for one year of advanced study at Massachusetts Institute of Technology's School of Industrial Management.

The following have received Institute of the Aerospace Sciences honors and awards: **Charles J. McCarthy**, who served as chairman of the board of directors of Chance Vought Aircraft, Inc. until his retirement in November, 1960, received the 1960 American Fellowship award. **Grover Loening** was awarded the Daniel Guggenheim Medal for 1960. Both **S. K. Hoffman**, president and **Thomas F. Dixon**, vice-president-research and engineer, Rocketdyne, Division of North American Aviation, Inc. have received The Louis W. Hill Space Transportation Award for 1960.

LEO M. CHATTLER has become vice-president and manager, Marine Equipment Department at Nortronics, Division of Northrop Corp. He was formerly vice-president, Raymond Atchley Division, American Brake Shoe Co.

GEORGE P. KNUDSEN has re-joined Highway Trailer Industries, Inc., as manager of the defense products division. Knudsen was formerly president of Metro Engineering & Mfg. Co., Inc.



NEW FORD PRESIDENT is John Dykstra (left) photographed shortly after Henry Ford 2nd (right) had announced his appointment. Ford remains as chairman of the board and chief executive officer.

JOHN DYKSTRA has been named president of Ford Motor Co. **HENRY FORD** 2nd remains chairman of the Board and chief executive officer.

Reporting directly to Dykstra in his new post will be the manufacturing staff and the vice-presidents in charge of the car and truck, Ford International, general products, stamping and power train, and defense product groups.

Reporting directly to Board Chairman Ford are the company's staff vice-presidents—finance, legal, industrial relations, product planning and styling, engineering and research, marketing, purchasing, and public relations.

Dykstra, who previously was Ford's vice-president, manufacturing, joined SAE in 1951. Ford has been a member since 1940.



PETER H. PONTA, formerly director of Ford's manufacturing and development office, takes over Dykstra's former duties with the title of director of manufacturing staff. Ponta is Detroit Section vice-chairman of production activity for 1960-61.



ROBERT J. HAMPSON in March was appointed manager of Ford Motor Co. Tractor Operations, which coordinates the operations of the Ford Tractor and Implement Division in the United States and the tractor operations now a part of Ford Motor Co., Ltd. at Dagenham, England. A month later, Hampson was named also to be a vice-president of Ford Motor Co.



Liddell



Famme



McVeigh



Baum



Groth



McMinn



Buschmann



Lumpkin

GEORGE J. LIDDELL, an SAE Director for 1961, is the writer of a new feature column titled "Rolling Along" in "Our Sun", internal house organ of Sun Oil Co. Announcing the new feature, the editor of "Our Sun" writes: "George J. Liddell, assistant to the Manager of Product Development at the Marcus Hook Automotive Laboratory, is the rare and happy combination of a technical person who can write, and a writer who understands technical things. Before joining Sun in 1935, he was an engineer at General Motors Proving Ground in Detroit."

JOSEPH H. FAMME, former director of manufacturing development for Convair Division of General Dynamics Corp., has been named assistant division manager-operations for Convair's San Diego operating division.

Famme will be in charge of all manufacturing operations, plant engineering functions and manufacturing development and processes specification activities.

ROBERT M. McVEIGH, assistant chief engineer, body engineering activity, Fisher Body Division, GMC, retired April 1, under the provisions of the General Motors Retirement Plan.

HARRY BAUM has joined the General Electric Co.'s Light Military Electronics Department as manager, scientific information and liaison. Baum was formerly project manager in charge of the preparation of engineering handbooks, product literature, and training literature for the McGraw-Hill Technical Writing Service.

QUENTON N. GROTH, formerly on special assignment in Argentina for Eaton Mfg. Co., has been appointed president and general manager of Eaton Ejcs, S.A.I.C., wholly owned subsidiary in that country.

ROBERT W. McMINN is now supervisor of Product Studies and State Certifications with Renault, Inc., at Maspeth, Long Island, N. Y. Until last November McMinn was a product development engineer in Chrysler Corp.'s Engineering Division.

PROFESSOR HEINRICH BUSCHMANN was awarded the degree of honorary doctor by the Technische Hochschule Stuttgart last February 17.

JAMES H. LUMPKIN, JR. has been named manager of Esso Standard's Automotive Division. Lumpkin was formerly assistant automotive manager for Esso Standard.

GEORGE E. BROWN has been appointed to the post of parts and service manager of Renault in charge of all parts and service operations in the United States. Brown was formerly assistant general service manager for Renault.

P. K. REICHBORN has become standards engineer at Norma-Hoffmann Bearings Corp. Reichborn was formerly project engineer—jet engines for Pan American World Airways.

ELMER J. SCHEUTZOW, who was formerly process engineer for the Cleveland Diesel Engine Division, General Motors Corp., has become production engineer for Aerojet-General Corp.

ROBERT M. KUHN has been appointed plant engineer for Aetna Standard Division of Blaw Knox Co. He was formerly staff test engineer at Peter Loftus Corp.

ROBERT W. MIDDLEWOOD, formerly manager, Lockheed Nuclear Products, Georgia Division, has been appointed director of quality assurance for Lockheed Aircraft Corp's California Division.

JEROME C. ROSENWALD has been appointed junior designer of The Oilgear Co. He was formerly junior engineer—automotive engineering, Bendix Products Division, Bendix Corp.

ROBERT A. BELL has been appointed vice-president, sales and engineering for Mohawk Spring Co., Inc. Bell was formerly chief engineer for American Spring & Wire Specialties.

THOMAS A. SULLIVAN has been appointed manager of maintenance at A. O. Smith Corp. Formerly he was manager of Granite City Plant for A. O. Smith.

WILLIAM C. NEWBERG has become a consultant to Detroit Broach & Machine Co., to advise the company in an expansion and diversification program. Newberg was formerly president of Chrysler Corp.

E. C. JETER has been appointed general manufacturing manager of the Engine and Foundry Division, Ford Motor Co. He was formerly manufacturing manager-foundries, Ford Motor Co.

DONALD F. DOMNICK has become planning-tooling manager for Caterpillar Tractor Co. He was formerly factory manager at Joliet for Caterpillar.

ROBERT W. OLSEN has been appointed senior project automotive engineer for American Oil Co. Olsen was formerly project automotive engineer, research department, Standard Oil Co.

RICHARD A. FLUME, JR., who formerly served Braniff Airways, Inc. as manager, West Coast engineering, has been appointed chief engineer for Braniff.

STANLEY G. THOMAS, who formerly served Convair-Astronautics, Division of General Dynamics Corp., has been appointed aircraft engineer for United Air Lines.

JOHN L. FROST, formerly connected with the forward truck planning department of Ford Division, Ford Motor Co., has become sales engineer, Transmission and Axle Division of Rockwell Standard Corp.

DAVID H. MIKKELSON has resigned as transportation manager for the Seattle Packing Co. to accept a position as maintenance superintendent for Consolidated Dairy Products Co.

AUGUSTUS B. WADE, formerly general sales manager, Fort Wayne Division, The Weatherhead Co., has been appointed general sales manager, Automotive Division, Weatherhead.

EVERETT H. SCHROEDER has been appointed president for the Astek Instrument Corp. Formerly Schroeder served as director of commercial sales at Kollsman Instrument Corp.

Schroeder is a member of SAE Air Transport Activity Committee and has served on SAE Aerospace Committees in past years.

ALAN R. COLLINS, formerly general manager and director of Investo Mfg. Co. has established his own consulting service, Metals and Processes where he is chief consultant.

EDWARD A. HAAS has been appointed to the sales department of Marshall Motor Supply. He was formerly connected with Automotive Shop Equipment sales. He was past chairman of SAE Oregon Section.

JAMES M. SMITH, formerly manager of the automotive engine section, Aluminum Co. of America, has been appointed to the new position of development manager, transportation in the company's development division.

JAMES L. ROBERTSON has been appointed to pipeline sales for Cities Service Oil Co. Formerly he was regional manager, industrial lubricant sales for Cities Service.

JOHN DALLAS GILL has been appointed chief engineer of Marine Systems Corp. He was formerly associate professor, mechanical engineering, University of Miami. Gill was faculty advisor for seven years to the SAE student section of the University of Miami.

JOSEPH D. LOVELEY has been appointed coordinator of manufacturing and engineering for Copeland Refrigeration Corp. Loveley was formerly assistant chief engineer in Chrysler Corp.'s central engineering, in charge of vehicle air conditioning, heating and ventilating.

GLENN HERZ has been elected as a vice-president of Hyster Co. He formerly served Hyster's Testing Division as supervisor and assistant chief engineer.

C. EDWARD BELLEW has been appointed manager of the manufacturing division of Garlock, Inc. Bellew was formerly vice-president and general manager of Baltimore Steel Co.

VICTOR P. VIDUGURIS has been appointed research engineer for Lockheed Missiles & Space Division, Lockheed Aircraft Corp. Viduguris was formerly design engineer at Bendix Corp.

LEO A. PFANKUCH, president of Shur-lok Marine Corp., has been elected as a new member of Telecomputing Corp.'s board of directors.

MAXWELL M. WACHOWIAK has been named manager of Motor State Products, Division of Dura Corp. He was formerly director of manufacturing for Minneapolis-Moline Co.

T. E. FRANKENFIELD has been appointed sales engineer at Laboratory Equipment Corp. He was formerly on active duty with USAF as chief, Fabrication and Modification Division, WADD, Wright-Patterson AFB, Ohio.

SAM POLLACK, who formerly served the Marine Division of Sperry Gyroscope Corp. as product development engineer, has been appointed senior design engineer at North American Aviation Corp.

JOHN PHINOS has been appointed construction superintendent at Goldmar Corp. Phinos was formerly fleet superintendent for Golden Creme Farms, Inc.

CHARLES F. TATE has been named engineer for Hercules Powder Co. Formerly he was associate engineer for Boeing Airplane Co.

Gill



Loveley



Herz



Bellew



Viduguris



Pfankuch



Wachowiak



Frankenfield



SAE National Meetings

1961

- June 5-9
Summer Meeting, Chase-Park Plaza, St. Louis, Mo.
- August 14-17
West Coast, Sheraton Hotel, Portland, Ore.
- September 11-14
"Heavy Duty Vehicle"¹⁰
(including production forum and engineering display),
Milwaukee Auditorium, Milwaukee, Wisc.
- October 9-13
Aerospace Engineering and Manufacturing (including
engineering display), The Ambassador, Los Angeles, Calif.
- November 9-10
Fuels and Lubricants, Shamrock Hotel, Houston, Texas

1962

- January 8-12
Annual (including engineering display), Cobo Hall, Detroit, Mich.
 - March 12-16
Automobile Week (combined National Automobile and Production
Meetings), Sheraton-Cadillac, Detroit, Mich.
 - April 3-6
Aeronautic (including production forum and engineering display),
Hotel Commodore, New York, N.Y.
 - June 11-15
Summer, Chalfonte-Haddon Hall, Atlantic City, N. J.
 - August 13-16
National West Coast, Biltmore Hotel, Los Angeles, Calif.
 - September 10-13
National Farm, Construction, and Industrial Machinery (including
production forum and engineering display), Milwaukee Auditorium,
Milwaukee, Wis.
 - October 8-12
National Aeronautic (including manufacturing forum and engineer-
ing display, The Ambassador, Los Angeles, Calif.
 - October 29-November 2
Combined National Fuels & Lubricants; Powerplant; and Transpor-
tation Meetings, Bellevue Stratford, Philadelphia, Pa.
- ¹⁰ Combined Farm, Construction and Industrial Machinery; Power-
plant; and Transportation Meetings

SAE Members

continued from page 115



Bussell

JOEL G. BUSSELL has been ap-
pointed project engineer for Form-
sprag Co. Bussell was formerly test
engineer at Huck Mfg. Co.

WALLACE C. ANDERSON, formerly
truck and fleet sales manager for S&C
Motors, has become sales engineer for
Petty Motor Co.

CHESTER J. SELDEN has been ap-
pointed assistant general manager for
Hartman Metal Fabricators, Inc. He
was formerly material handling engi-
neer of Parke-Davis & Co.

C. L. COWDREY, formerly manager
of Luton Division of D. Napier & Son,
Ltd., has been appointed general
manager of Luton.

EARL C. DAVIS has been appointed
mobile equipment sales manager for
Parker Hannifin Corp. He was for-
merly sales manager for the company.

DR. R. D. O'NEAL has been elected
vice-president in charge of engineering
at Bendix Corp. O'Neal was formerly
general manager of the Systems Di-
vision, Bendix Corp.

LOUIS E. BENTON has been ap-
pointed director of sales of Burlington
Mills, Inc. Benton formerly served
Brummer Seal Co. as sales manager.

Obituaries

E. J. COSFORD . . . (M'32) . . . man-
aging director, Federal Commerce and
Navigation Co., Ltd., . . . died February
21 . . . born 1894.

ROBERT W. EDWARDS . . . (M'53)
. . . assistant maintenance manager,
Edwards Motor Transit Co. . . . died
October 15 . . . born 1920.

ROSS J. KITTLE . . . (M'47) . . .
works manager, Thompson Products
Division, Thompson-Ramo-Wooldridge
Corp. . . . died February 28 . . . born
1914.

NORMAN LEEDS, JR. . . . (M'28)
. . . assistant general manager, Ray-
bestos Division, Raybestos-Manhattan,
Inc. . . . died March 12 . . . born 1901.

A-6 Achievements Noted at 50th Meeting

TWENTY years of progress by Committee A-6, Aerospace Hydraulic and Pneumatic Systems and Equipment, brought praise from SAE President A. A. Kucher during the group's 50th meeting held April 17-21 in Detroit. In a brief address, Dr. Kucher drew the attention of over 200 engineers to unique achievements. Noted were:

- Some 125 major technical recommendations made to the military services
- Recent work on high-temperature systems and contamination control problems
- Vigorous support of symposiums on timely subjects to supplement standards work, and

- Attendance figures of approximately 200 at each semi-annual meeting.

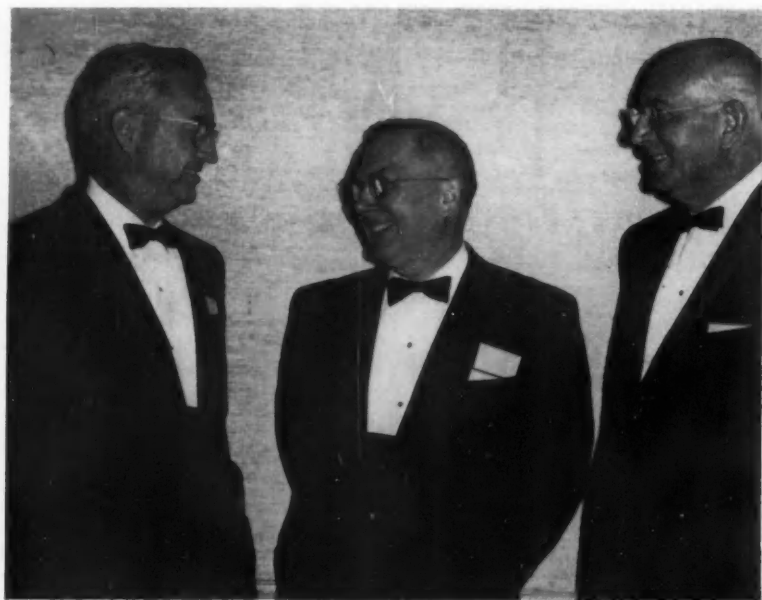
During the recent 5-day meeting, A-6 created a new panel to look into hydraulic problems of commercial jet transports. Its ultimate aim: To develop recommendations which would prevent the recurrence of malfunctions. The panel will collect all available data prior to analysis.

Future A-6 activity on metallic seals was also discussed. This work will be performed by another new panel whose assignment is to prepare needed standards and specifications and to serve as an information center on industry metallic seal programs.

A-6 Chairman B. R. Teree (r.) chats with SAE President Kucher (center) after a session. With them is F. H. Pollard, the Committee's vice chairman.



Over 200 hydraulic and pneumatic experts attended A-6 meetings which went on for five days.



At Dinner Dryden

TOASTMASTER F. W. FINK (left), vice-president and chief engineer of Ryan, and SAE President A. A. Kucher (right) relax with Dr. H. L. Dryden, deputy administrator, NASA, before the dinner at which Dr. Dryden talked on "Aeronautical Research in the Sixties."

In his speech, Dr. Dryden emphasized that NASA has responsibilities in aeronautics as well as in space.

Among the aeronautic researches being carried on by NASA, he discussed the variable-wing-sweep aircraft, which, in its early configurations, he said, had left much to be desired. Recent wind tunnel tests have shown, he continued, that a variable-wing-sweep configuration can be designed to have small center of pressure movement and

Engineers keep feet on ground



SAE PRESIDENT A. A. KUCHER (right) presents plaques to G. W. Periman (left) and E. W. Conlon, cochairmen of the committee that arranged this meeting.

Speaks on NASA Research . . .

would require much less weight than did earlier designs. The NASA, he added, is not advocating this concept for supersonic transports, for much more work is needed before such a recommendation could be made.

For the supersonic transport, he suggested that a hybrid engine — figuratively a "rubber engine" — with a configuration that varies with altitude and speed might be the ticket. The problem with these planes, he said, is to maintain as high an efficiency as present jet transport engines at subsonic speeds and nearly twice this efficiency at supersonic speeds. A new engine will have to be developed, he added, rather than using a modification of an existing design, and it probably won't be available before the 1970's. He predicted, though, that when it is capable of attaining speeds as high as Mach 3,

it should be one of the lightest and most efficient prime movers ever built.

At such speeds, the airplane skin may be subjected to temperatures up to 550 F . . . and to be economically feasible, he said, the supersonic transport must have a flight life of 30,000 hr, in cyclic periods of 2-3 hr. NASA, he reported, is just beginning to explore the problem of adequate materials for such a plane. He said that, at the moment stainless steel and titanium alloys look most promising as the structural materials for the airframe.

For the engines, he said, NASA and private industry has been developing experimental alloys that utilize intermetallic compounds, rather than carbides, for strengthening. These appear to promise increased life and permit higher operating temperatures.

while planning space ventures

- The spring National Aeronautic Meeting program showed that developments in cargo and other types of purely earth-bound planes are not being neglected, while work on missiles and space vehicles gets the headlines. Present status of supersonic transport plane was well discussed.

WITH supersonic planes, missiles, and spacecraft getting all the headlines these days, it was refreshing to find, at the spring National Aeronautic Meeting, held in New York on April 4-7, other more prosaic, but important phases of aircraft engineering receiving a good share of attention in the 87 papers presented during the week.

Thus, there were papers on cargo planes and handling equipment, VTOL aircraft, jets of the USSR, turbine noise, flight control systems, industrial and marine applications of jet engines, piloting techniques with jets, sonic and aerodynamic fatigue, high-temperature materials, and hydrofoil boats.

A variety of production topics was covered in a series of papers and panel discussions on: product reliability, developing management personnel, joining materials for high-temperature service, material forming, stock removal, and use of mathematical models in management decision making.

And the headline subjects weren't neglected either. For example, a whole day was devoted to discussing the supersonic transport at what was the first open forum on this type of plane since the President announced that the government, through FAA, is planning to investigate the feasibility of the supersonic jet airliner.

Then there were papers on nuclear ramjets and rockets, application of reliability theory and techniques to spacecraft design, auxiliary power for space vehicles, thermal environment of interplanetary space, assembly and maintenance of space vehicles, recovery of space vehicles, various versions of propulsion systems for missiles and space vehicles, and propulsion systems for underwater missiles.

In addition to this comprehensive and meaty technical fare, there was a less technical side to the meeting, which included two luncheons and a dinner. These gave those attending the meeting a chance to hear knowl-

edgeable speakers on important topics of the day:

- Najeeb E. Halaby, head of the Federal Aviation Agency, who discussed some of the FAA's plans for the future, particularly with regard to the development of a supersonic plane.

- Army Secretary Elvis J. Stahr, jr., who discussed the Army's role in aviation.

- Hugh L. Dryden, deputy administrator of NASA, who outlined NASA's research program and what it means to industry.

- H. G. Conway, chief engineer of Short Bros. & Harland, Ltd., Belfast, Ireland, who described an experimental VTOL plane that uses one jet engine to lift itself off the ground and land it, and another for forward propulsion.

Both the Manly Memorial Award and the Barbour Award were presented at luncheons during the meeting.

Wednesday evening was designated "Student Engineers Night," when students of local engineering schools were invited to inspect the Missile and Aircraft Engineering Display, and then to hear recent graduates discuss their experiences, so far, in industry. They were also invited to attend that evening's technical session on space vehicles.



Halaby discusses

NAJEEB HALABY (right), Administrator of the Federal Aviation Agency, listens quizzically while Luncheon Toastmaster William Littlewood, American Airlines, extols the virtues of the Eastern Shore (Md.), before the Wednesday Luncheon at which Halaby was principal speaker.

Halaby told the luncheon audience that there was no question about it — a supersonic airliner would be built. The questions were: when? and how? In his opinion, the "when" would be "1970 plus or minus a year or two" as the date for initial service. He pointed out that, although he had no preconceived notions in the matter, some people were saying that we should go right to Mach 3 while others favor an interim Mach 2 plane.

Prevailing thinking in this country, he reported, is that there is no point in starting with anything less than the

Engineers keep feet on ground while planning space ventures

... continued

Conway and Stahr Speak at Tuesday

H. G. CONWAY (left in the photo at right), Short Bros. & Harland, Ltd., Northern Ireland, and Army Secretary **Elvis J. Stahr, jr.** (center), speakers at the Tuesday luncheon, are shown with the Luncheon Toastmaster **J. T. Dymant**, chief engineer, Trans-Canada Air Lines.

In his speech, Conway described an experimental vertical take-off plane — the Short SC 1 — that uses one jet engine to lift itself straight up off the ground and another for forward propulsion. The ostensible waste of having two separate powerplant systems is compensated for, he asserted, by the possibility of operating each engine at its maximum performance efficiency.

The SC 1, which rises from a horizontal position (in contrast to some VTOL aircraft, which take off from a tail-sitting position), also has the stability to hover, or come down slowly, if its forward propulsion engine fails.

An autostabilizing system, which makes use of air reaction forces at nozzles at the extremities of the plane, stabilizes the plane during hovering.

At first it had been difficult to achieve a smooth transition from the hovering state to forward motion, Conway reported, but in the past year some 150 transitions have been made. Piloting the plane through the transition state is no longer particularly difficult; but cockpit routine is still complex and requires concentration.

Conway feels that, for long-range supersonic VTOL aircraft, the "separate lift" design was more promising than the VTOL planes that use a single engine that "lifts" and then "tilts" to another position for forward motion. He also suggested that a VTOL aircraft, such as the SC 1, would be a powerful low-level strike aircraft that could be used without alternation by Army, Navy, and Air Force.

Secretary Stahr pointed out that the advancement of Army aviation is

bringing about a revolution in the Army's ability to surmount the obstacles of time and terrain in the movement of troops, weapons, and supplies, and to ensure continuously effective control over its deployed units. Furthermore, he continued, the contributions of Army aviation to effective combat surveillance are helping immeasurably to extend the vision of the commander . . . to provide him with detailed battlefield information of unprecedented scope, accuracy, and timeliness, which vastly increases his ability to make prompt and valid command decisions.

He said, however, that the Army needs aircraft that are simpler to maintain, with greater capacity, better performance, and a far greater ability to land and take off from very small, unimproved areas anywhere on earth. The Army requires a much better capacity to operate its aircraft under conditions of severely restricted visibility or at night. It must have, he con-

supersonic transport . . .

Mach 3 ship; whereas the British appear to favor equally strongly the Mach 2 plane as a starter.

Halaby gave four reasons why it was important for us to develop the supersonic transport as soon as possible:

- It would advance our technology. For example, we would have to learn how materials would stand up in near-space environments and at high speeds. The plane's surface would be heated to something like 500 F, a temperature at which all but special paints would be burned off.

- National security. The armed services, in certain situations, might need a troop carrier to travel 3500-4000 nautical miles in a couple of hours. The B-70, he pointed out, is not a troop carrier.

- National prestige. He warned that the United States is in danger of losing

its traditional lead in aviation, "particularly as we go off into orbit." A supersonic plane would help to restore our leadership.

- Economic — the main reason. Such a plane would create traffic, deliver goods faster, give executives more time, and help increase our export trade.

Halaby outlined some of the problems that must be solved before such a plane becomes a reality. Electronic-mechanical instruments to control stability will have to be developed because such a plane won't have natural stability. New safety standards will have to be set. Computers will have to be developed to guide the flight from take-off to touchdown. Pilots will become monitors of the equipment, rather than navigators and communications officers. Air traffic control facilities will have to be revised drastically.

Luncheon . . .

tinued, air vehicles that are able successfully to defend themselves by one means or another against hostile fire. It should be able to move much more quietly. "We are asking a great deal," he said, "but we have every confidence that the challenge will be met, because we have confidence in you."

"Is is imperative," Secretary Stahr emphasized, "that industry contribute its best thought to our defense planning, and play an active role in every phase of material development. As a full partner in defense, it should apply itself with foresight, initiative, and imagination to the evolution of new ideas, which could contribute to the Army's effectiveness. It should, if possible, go forward even further and faster than the Army itself in anticipating demand by applying its own great resources, on its own volition, to the exploration of every field of science and technology in search of better methods and means of carrying out the Army's tasks."





1.

1. **GROVER LOENING** (right) presenting the certificate and medal of the 1961 Laura Taber Barbour Air Safety Award to **E. I. R. Mac Gregor**, Civil Air Attaché of the British Embassy, Washington, who accepted in behalf of the recipients, **E. S. Calvert** and **J. W. Sparke** of Great Britain's Royal Aeronautical Establishment, who were unable to attend the presentation.

The winners received the award for their "major contribution to world air safety through joint development of the Line-and-Bar Approach Lighting System and the Visual Glide Path Indicator now installed and in use at many major airports."

At present the winners are jointly investigating the avoidance of in-flight collisions.

Loening was the first aeronautical engineer hired by the Wright Brothers and also the 1960-1961 Barbour Award Board chairman.



2.

2. **DR. DONALD B. MACKAY** (left), of the Missile Division, North American Aviation, Inc., shown holding the medal representing the 1960 Manly Memorial Award, which he received from **R. E. Johnson** (right) for his paper, "Secondary Power Systems for Space Vehicles." The paper was judged the best SAE paper presented in 1960 in the field of aerospace propulsion. Johnson is chairman of the Manly Board of Award.

3. **J. G. LOWRY** (left), chairman of the Air Transport Engineering Activity Committee, talks over the success of the meeting with **H. W. Zipp** (center), chairman of the Aerospaceshaft Engineering Activity Committee, and **D. D. Streid**, chairman of the Aerospace Powerplant Engineering Activity Committee. Not shown is **K. O. Tech**, chairman of the fourth participating group, the Production Engineering Activity Committee, who was not able to be present.

4. **B. H. SLATTER** (left) and **P. H. Young**, Bristol Siddley Engines, Ltd., were two authors who crossed the ocean from England to present papers at the meeting.

5. **LT.-GEN. E. J. O'NEILL** (left) Commanding General, First U. S. Army, Governors Island, chats with **Major-Gen. R. D. Meyer**, Principal Assistant for Aviation, Chief of Transportation, Department of the Army. General Meyer was chairman of the technical session on VTOL-STOL aircraft.

6. **CLEARANCE WAS REQUIRED** to get into the classified session on propulsion for missiles and space vehicles. Above, registrants lined up to show that they have been properly cleared to attend the session.

7. **FOR THE FIRST TIME**, all the papers at a national meeting were prepared in the new, improved, integrated preprint. The papers were displayed as shown above, a la supermarket, making it easy for people to look before they bought.

5.



8. **AUTHOR FROM FARTHEST AWAY** was **Capt. P. W. Howson** (left), manager, flight operations, for Qantas Empire Airways, Ltd., of Australia. (Shown behind him is **Harold Hoekstra** of FAA.)

9. **DAN BEARD**, assistant vice-president, safety, American Airlines, is shown here with some of the airline hostesses who distributed flowers supplied and flown in by the various airlines serving the Metropolitan New York area. Beard was a committee of one in charge of the project that made the flowers available.

**Engineers keep feet on ground
while planning space ventures**

... continued

SAE JOURNAL



3.



4.



6.



7.



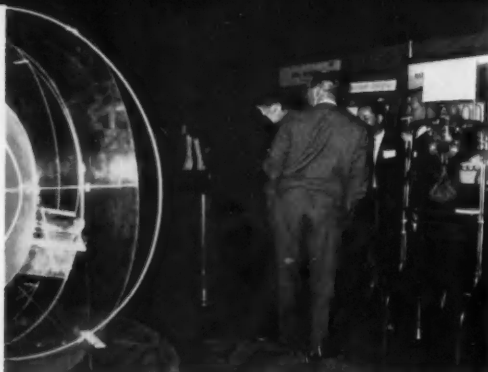
8.



9.

Engineering Display

...



POPULAR ATTRACTION of the meeting was the Missiles and Aircraft Engineering Display at which manufacturers of systems and components from all over the country (and one from Canada) displayed — and in some cases demonstrated — their wares.

Heard at the Production Panels . . .

• **TWENTY-YEAR VETERANS** — as well as the younger engineers — are going back to school. Rapidly changing technology in the aerospace industry is requiring less specialization, more training in fundamentals.

• **MANAGERS** are primarily sales people; they must be able to sell their ideas and decisions to subordinates.

• **UNPOPULAR DECISIONS** by management often are the result of poor communication and misunderstanding.

• **GOOD MANAGERS** aren't born — they're made.

• **IMPACT MACHINING** is being used to cold extrude metals that were formerly necessary to machine completely.

• **OBJECTIVES** of a management development program should be to develop openminded, flexible, and adaptable people.

• **GOOD MANAGERS** are flexible, openminded, and have capability for self-improvement. They make positive decisions and stand up for what they believe.

• **MANAGEMENT DEVELOPMENT** takes place in two ways, on-the-job training and off-the-job training.

• **MANAGEMENT TRAINING** is only as effective as the person using the training.

• **MANAGEMENT DEVELOPMENT PROGRAMS** are often a self-development motivating force for those not included in the programs.

• **RELIABILITY** is everybody's business.

• **RELIABILITY** provides a measuring stick for corrective action.

• **LUBRICANTS** containing free graphite have caused problems on aluminum airplanes.

• **THE MORE PARTS** per product, the more reliable each part must be.

• **WOULD YOU BUY** a car containing 720 parts each of 99 44/100% reliability? Probably not, since overall reliability of the vehicle would be only 1 7/10%.

• **A PART OF PREDICTED RELIABILITY** is a price of progress for which the customer will willingly pay.

• **NO RELIABILITY PROGRAM** is worth a damn unless you control your raw materials.

• **THE QUALITY CONTROL MAN** often acts as the middle man between the manufacturing shop and the design engineer in a reliability program. He acts as a sounding board, passing on information from one group to the other.

• **GOOD MANAGERS RELATE WHAT THEY LEARN TO THE JOB.**

• **ALL PRODUCTS** meet some sort of life test as part of a reliability program. Information on any parts which don't meet specified life must be fed back to engineering for investigation and correction.

• **GUN DRILLING** is applicable to the nickel-based super alloys. High accuracy holes with excellent finish can be obtained when correct cutting conditions are used.

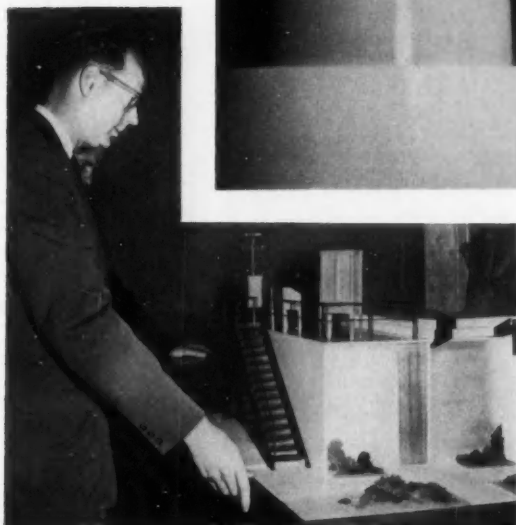
• **THE ONE BIG DISADVANTAGE** of explosive forming is the excessive time needed to load and unload the part from the die. Kirksite, ductile iron, and concrete dies with epoxy faces are among successfully used materials. Titanium, molybdenum, and other refractory metals can be explosive-formed at high temperatures.

• **ELECTROLYTIC GRINDING** is being used for stock removal of carbides, steels, and some of the newer exotic materials.

• **WHEN COMPUTING EQUIPMENT** is available, the size of the problem, as such, need not deter us. However, computing time (and hence cost of computing) varies approximately as the cube of the size of the problem, and data gathering may be made more difficult in the problem of larger size. Accordingly, any simplification that can be introduced by managerial judgment or policy is desirable.

• **PURCHASING, engineering, quality control, and manufacturing** are all members of the reliability team.

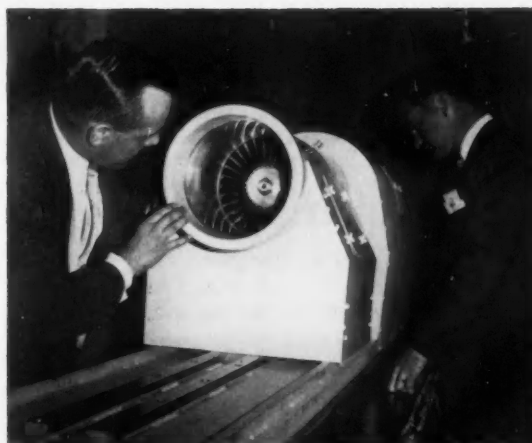
Exhibits for Technical Papers



MODEL of General Electric's solar test facility, now under construction at Phoenix, Ariz., was described by D. C. Miley, Space Power Engineering, Missile & Space Vehicle Department, GE. The building shown at left houses the test monitoring equipment, and support equipment for energy conversion devices. Heart of the solar test facility is the radar antenna mount (model shown above right), to be used for holding the solar collectors.



AN IBM 650 magnetic drum data processing machine (above), an IBM Read and Punch Machine, and an IBM 407 Accounting Machine were used during the session on "Computers and Mathematics: Management's Master or Slave" to help solve an actual problem that management might be called on to make. The problem was presented in the form of specifications for a new missile, Company X's hypothetical "Exterminator."



PRATT & WHITNEY'S COMPRESSOR NOISE RIG was demonstrated by John Tyler and T. G. Sofrin of PGW. The machine simulates inlet noise of an engine. Both inlet guide vanes and exhaust guide vanes can be changed, so that one can demonstrate the noise producing ability of many different configurations.



FACULTY ADVISERS from four New York area colleges received certificates of appreciation for having served as faculty advisers for at least one year. Myron Levitsky (inset, left), New York University faculty adviser, is shown receiving his plaque from Metropolitan Section Vice-Chairman L. A. Douglass.

Top, left to right, are: Albert G. Feil, Academy of Aeronautics faculty adviser; Charles Baum, who accepted the plaque for Prof. A. J. Del Vecchio, Manhattan College faculty adviser; Douglass, who presented all four plaques; and F. A. Tedesco, Academy of Aeronautics faculty adviser. The presentations were made as part of the Student Engineers Program, on Wednesday evening, held by SAE Metropolitan Section in co-operation with SAE Student Branches in the New York area.

Engineers keep feet on ground while planning space ventures

... continued

"FACTS OF LIFE IN INDUSTRY" were brought to light by a panel of five '58, '59, and '60 graduates from New York area engineering schools. The panel (left to right): **William Bautz** of Manhattan College, Remington Rand Corp.; **John Palumberi** of the Academy of Aeronautics, Grumman Aircraft Engineering Corp.; Francis Camps-Campins of New York University, American Machine & Foundry Co.; **Richard Marschean** of City College of New York, American Electric Power & Service Corp.; and Edward Mayer of Stevens Institute of Technology, Ardo Associates.



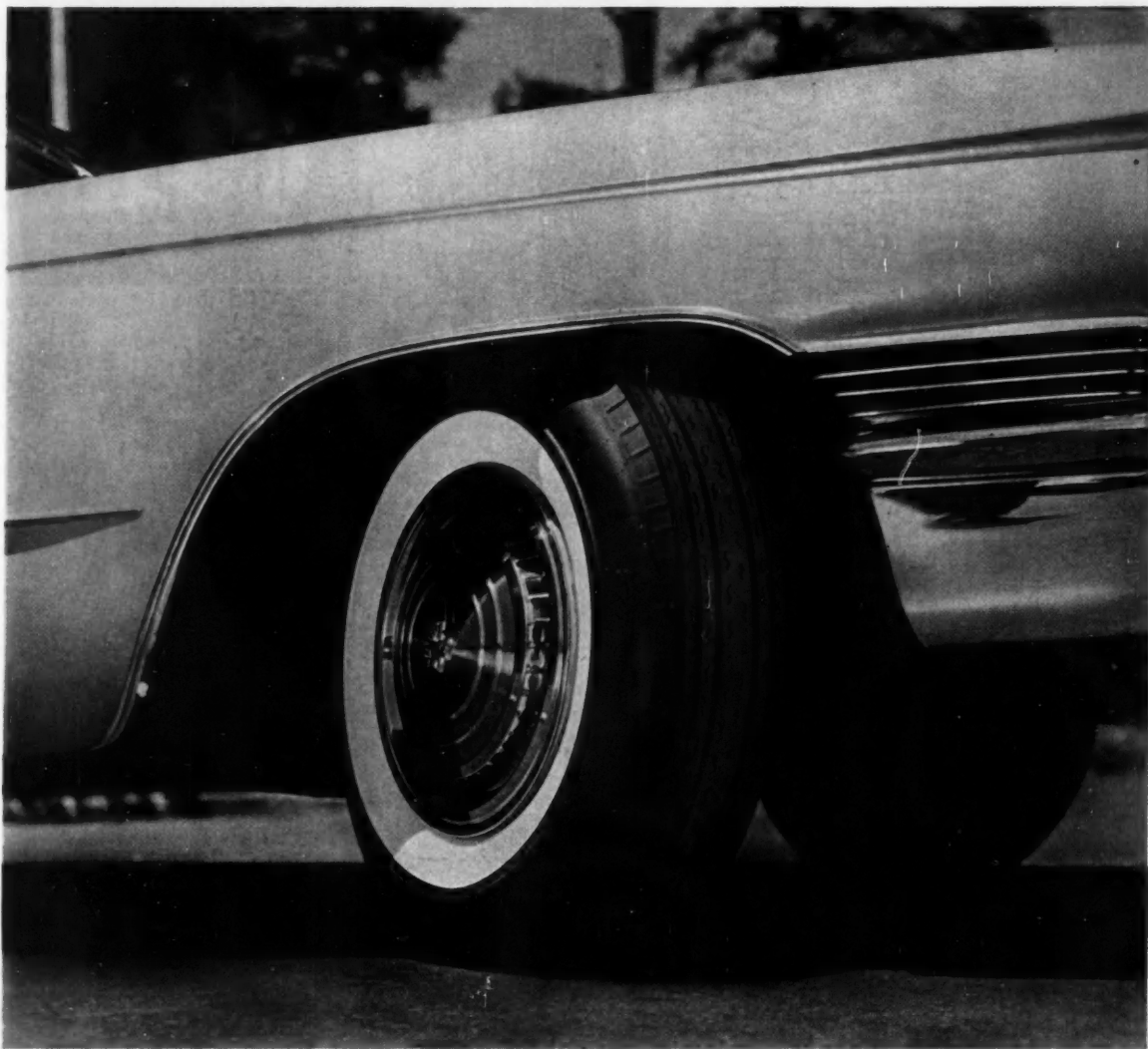
T. B. RENDEL (left), assistant to the vice-president, manufacturing, Shell Oil Co., with R. L. Courtney, Ethyl Corp., SAE Metropolitan Section Vice-Chairman for Student Activity. Rendel was moderator for the panel "Facts of Life in Industry."



STUDENTS tour the SAE Missiles and Aircraft Engineering Display at the Aeronautic Meeting on Wednesday evening.



What's News in Rubber...



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Long familiar to the auto maker in quality rubber parts for demanding jobs, Enjay Butyl rubber is now available in tires. Butyl tires that have been proven by billions of miles are now sold by several leading tire manufacturers.

Who will be first to capitalize on the growing acceptance of Butyl to give new-car sales a boost? Consider the advantages: Butyl hugs the road with

a sureness never felt before. Takes sharpest turns with full traction—yet without a squeal. Virtually floats over bumps—without bounce. Makes cars ride quieter too. And gives quicker, safer stops—even on wet roads. Butyl tires keep that shiny new-tire look for years.

Enjay does not make tires. It supplies Butyl rubber to manufacturers of tires, tubes, automotive parts and

hundreds of other fine products. For more facts about this remarkable new rubber, contact Enjay's Detroit Area Office, 17360 West Eight Mile Road, Southfield, Mich. Phone KENwood 2-7113.

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HEATING AND VENTILATING DIVISION

New Type Batteries Have Promising Future

Based on paper by

**C. G. GRIMES and
W. S. HERBERT**

Carl F. Norberg Research Center,
Electric Storage Battery Co.

NUCLEAR batteries and fuel cells are undergoing intensive research, and both have a high potential for portable, packaged power.

The development of a high rate, high energy density, inexpensive, nuclear battery awaits new knowledge and, while the technical art in this field is advancing, systems currently suffer from low efficiencies, low energy densities, and high costs.

Remarkable progress has been made in developing a practical fuel cell, but it is still a few years away. Most of the work done to date involves the use of hydrogen or mixtures of hydrogen and hydrocarbon as the fuel, and oxygen as the oxidizer. Interest in the fuel cell is centered on its potential as a power generating source, but it also has promise as a chemical reactor producing both power and a useful byproduct when carbonaceous fuels are used. Likewise, the fuel cell electrode system is readily adaptable for chemical processing.

Fuel Cell as Storage Battery

A fuel cell has two major components—the "active materials," or fuel and oxidant, and the "reactor," which comprises the assembly of catalytic electrodes, fuel and oxidant handling systems, and product disposal system, electrical connections, electrolyte, and container. Regardless of the watt-hour capacity of the unit, there is a definite, fixed weight and volume attributable to the reactor. This in turn is related directly to rate and voltage. The fuel cell, therefore, is at a decided disadvantage—weight and volumewise—when the demand for a continuous power supply is of relatively short duration.

The theoretical hydrogen-oxygen fuel cell using fuel storage in the solid state to reduce weight will have a lower w-hr/lb-rating than will a sealed silver-zinc battery when the duration of continuous power demand is less than 6 hr. Compared to the lead-zinc battery, the crossover point is slightly in excess of 1 hr. For the solar converter in 100% light, the values are 10 hr and 1.5 hr, respectively.

There are many possible types of fuel cells, varying in complexity as well as efficiencies. The more complex type will be best suited for fixed installations while the simpler ones will have more use as portable units. It now looks as if the fuel cell would create its own markets as an extension, rather than a replacement, of battery

applications. The fact that the cell is theoretically feasible gives enough incentive to assure eventual success with it.

(Material in this article is drawn from one of 12 papers included in SAE Technical Progress Series, Volume 3: Storage Battery Symposium—1961. To order this publication, TPS-3, see p. 6.)

SAE Battery Test Equipment Improved

Based on paper by

R. D. BREWER

Ford Motor Co.

THE SAE Storage Battery Test for cycling life has proved to be a valuable tool for evaluating the durability of internal components and is regarded as an important gage of battery quality for use in procurement. It was first approved in January 1936 and was last revised and reapproved by the SAE Storage Battery Subcommittee, the Electrical Equipment Committee, and the Technical Board in May 1960.

The decision to improve the design of the stand and incorporate more modern concepts was made at Ford when an expansion in the quality control program necessitated the acquisition of more stands. The stands in use, built to comply with provisions for type B equipment as described in SAE Technical Bulletin TR-33, had given valuable service for many years, but failed to meet modern requirements for safety, accuracy, and flexibility. The objectives sought in the new design were:

1. Greater safety by reducing the voltages that might be met on exposed battery leads and terminals from 240 to 70 v d-c.
2. Improvement in accuracy of control of amp-hr during the automatic cycling for better uniformity of test conditions.
3. Regulation of the timing of the cycle switch-over so that scheduling of check-out tests could be made more definite.
4. Employment of a-c for a power source. Existing d-c source is to be discontinued at some future date.
5. Greater convenience in handling batteries and in switching and control.
6. More efficient utilization of floor space in accomplishing the foregoing objectives.

Three new test stands were built and placed in service early in 1960. To date, their performance has been well up to expectations. There is a marked improvement in the accuracy of control and the uniformity of test conditions. It is too early to predict the

continued on page 130

Compressed Air Data You should have about damage caused by Water, Vapors, Acid fumes and Abrasives in the Air System



A study and discussion of compressed air and its inherent properties which cause corrosion, contamination, abrasion and freezing of pneumatic equipment are covered in 16-page brochure "Moisture Control."

Now in its 26th printing, the brochure explains how the unique, low-cost Van-Air method extracts water, vapors, acid fumes and abrasives which normally flow past aftercooler and receiver—how these elements corrode pneumatic equipment and controls—damage products in process—contaminate exposed solutions.

The method (which operates for less than ONE-CENT per 18,000 cu. ft.) requires no heat or power—no regeneration—delivers air dry, clean, sterile and non-toxic. Now used in hundreds of different applications in all types of plants—large and small. The method can treat any volume of compressor output from minimal air for smallest instrument, gage, tool, etc. to total air for entire plant. It has no capacity limit. Ask for brochure—free on request.

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Photo courtesy Cushman Motors

R/M found friction material answers for versatile Cushman Trailster

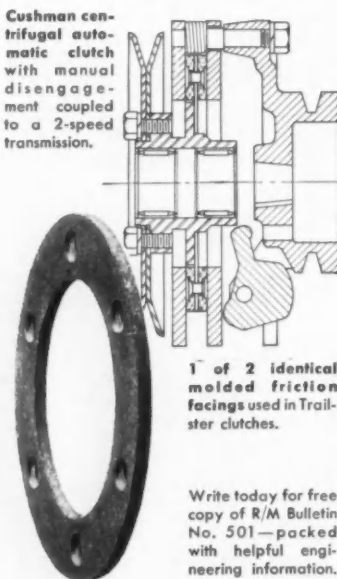
"We placed our friction problems for the Trailster's centrifugal automatic clutch in Raybestos-Manhattan's hands," says R. D. Von Seggern, assistant chief engineer, Cushman Motors, Lincoln, Nebr.

"Cushman has been using Raybestos-Manhattan friction materials in various models of utility vehicles for over 15 years. Based on past experience, we know we can rely on them for assistance at every stage—from design to production.

"We needed a friction material capable of withstanding high heat generated by slippage until the centrifugal clutch engaged. It had to have a uniform coefficient of friction over a wide temperature range and low wear characteristics. R/M was able to develop a molded material which meets these requirements."

Why not take a tip from Mr. Von Seggern—call on us and make use of our knowledge of friction accumulated from 50 years of experience. Just phone or write—a sales engineer can be at your desk within 24 hours. Remember . . . *only R/M makes all types of friction materials*; your assurance of unbiased council.

Cushman centrifugal automatic clutch with manual disengagement coupled to a 2-speed transmission.



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life of the various components of the stand. Maintenance costs will run somewhat higher because of the larger number of active elements in the control system, but indications are they will not be excessive.

(Complete paper includes a list of major components and schematic diagrams and details to help anyone wishing to build a stand for his own use.)

(Material in this article is drawn from one of 12 papers included in SAE Technical Progress Series, Volume 3: Storage Battery Symposium—1961. To order this publication, TFS-3, see p. 6.)

Tests Reveal New Battery Separator Data

Based on paper by

J. A. ORSINO and
E. J. DUNN, JR.

National Lead Co.

RECENT investigations have revealed interesting data about pore sizes in various commercially available separators. Among them:

Total porosity of the separators studied varied from 55 to 65% by volume of the separator.

Separators may vary appreciably in the flow of air through the separator from 462 to 0.5 cu in. per min per sq in. at 1-in. head of water.

The thinnest separators tend to have the lowest resistance.

Separators may have the equivalent of up to 20% blocking area interfering with the ionic path.

Many separators are weak when tested across the ribs.

Some separators will not withstand the effect of strong oxidizers.

It appears that minimum ionic-path length through the separator commensurate with the strength and blockage of active material is important.

Separators that wet easily with H_2SO_4 or allow ready diffusion of acid or even force diffusion by capillary action should aid certain sustained discharges.

Separators should maintain dimensional stability, should not induce any contamination in the battery, and should have satisfactory resistance to sulfuric acid and battery reactions at temperatures up to 180 F or higher.

(Material in this article is drawn from one of 12 papers included in SAE Technical Progress Series, Volume 3: Storage Battery Symposium—1961. To order this publication, TPS-3, see p. 6.)

Briefs of SAE PAPERS

continued from page 6

Mechanism of Tire Thump and Roughness, H. S. RADT, Jr. Paper No. 322C. Results of study made by Vehicle Dynamics Dept. of Cornell Aeronautical Laboratory, first phase of which was to determine properties of actual sound measurements which characterize severity of thump and roughness to observer; CAL concept of mechanism described as transmission of vibrations from excitation to destination at observer in car; research conducted to relate sound recordings, as measured on road, with intensities of thump and roughness as determined by passengers in car.

Forces and Torques Associated With Roughness in Tires, S. A. LIPPMANN. Paper No. 322D. Examination of mechanical events underlying roughness shows that tires can be involved in at least five ways; various approaches, methods of measurement and machines used to evaluate nonuniformities of tires; comparison of few types of structural aberrations illustrating problem of providing all inclusive roughness rating for tires.

Effect of Loaded Radial Runout on Tire Roughness and Shake, L. M. MORRISH, R. R. HAIST. Paper No. 322E. Loaded radial runout is defined as dimensional departure from true radius which footprint to tire takes while running loaded, thus forcing its center to describe corresponding motions; test machine, based on concept, and results of tests; analysis of recordings and correlation to car motion; program for testing tires at Buick Div.; comparison of tire evaluation on Goodyear loaded force variation machine, on Buick loaded radial runout machine, and, by Goodyear, for various free runouts and force variations.

Tire Dynamics — Effect on Noise and Vibration, J. W. LISKA, J. SIDLES. Paper No. 322F. Two different approaches were studied by Firestone Tire and Rubber Co. in evaluating effects of tire induced noises and vibrations on car; isolated tire tests and testing machine to study dynamic characteristics of isolated tire; tire induced axle motions and their effects on car noise and vibrations; VANA apparatus consisting of data recording unit, portable power supply for data recording unit and data reduction equipment; results obtained.

Dimensional Analysis of Vehicles Why, How, What, J. NAGY, A. SELIGSON. Paper No. 325B. Function of

dimensional analysis group at Ford Motor Co. in analyzing prototype and current production vehicles for comfort, seating, visibility, ride and handling characteristics; relationship of group with body and chassis design and development activities; test techniques and equipment used in obtaining information.

Tractor-Scraper Performance Evaluation Using Digital Computer, D. A. LEWIS and W. C. MORGAN. Paper No. S297. Shows that considerations were made and what techniques were employed by Caterpillar Tractor Co. in simulating the performance of tractor-scraper vehicles and illustrates how the simulation is used to evaluate and compare new and existing machines.

Lancer Ride and Handling Story, G. W. GIBSON. Paper No. S281. A specific, easy-to-understand description of the problems faced and how they were met trying to provide in a compact car ride and handling quality close to that of a standard sized car. "Ride" is defined as having to do primarily with carrying of vertical loads and isolation of road-originated dynamic forces; "handling" as having to do with lateral support given a car by tires and suspension systems.

High Pressure Hydraulics for Earth-moving Vehicles, C. F. GARNEY. Paper No. S284. Sketches briefly the fluid characteristics under high pressure which may affect hydraulic system design. Says physical characteristics of most fluids are subject to change as pressure and temperature fluctuate.

MATERIALS

Plastics and Profit Squeeze, R. F. McCABE. Paper No. 321A. Plastics were used with caution by automotive industry over past decade, particularly in engineering applications as opposed to decorative uses; factors leading to increased use are shown; mounting costs for tooling and finished parts; efforts made by plastic industry in developing new materials; extensive use of plastics in Europe as functional engineering materials; principal generic types, engineering areas where they are used, and cost per cu in. are given; recommendations.

MISCELLANEOUS

Fundamental Characteristics of Hydrofoil Craft, I. PALMER, J. K. ROPER. Paper No. S273. A history of hydrofoil supported craft, starting with Enrico Forlanini's 45 mph "flying" boat of 1905, to the Maritime Administration's new test vehicle; some basic fundamentals of hydrofoils and current thinking as regards powerplants; future plans for 500 passenger design and military applications.

Instrumentation and Test Procedures, J. LORCH. Paper No. 315B. Measurement of interference, gener-

continued on page 132

Bonded, rivetless, aluminum-cored structure of the Douglas A4D Skyhawk's rudder section prevents skin-crack failures. Conventional riveted structure could not stand pre-service load and vibration tests. Sonic flight vibration would have caused cracks between rivets on skin.

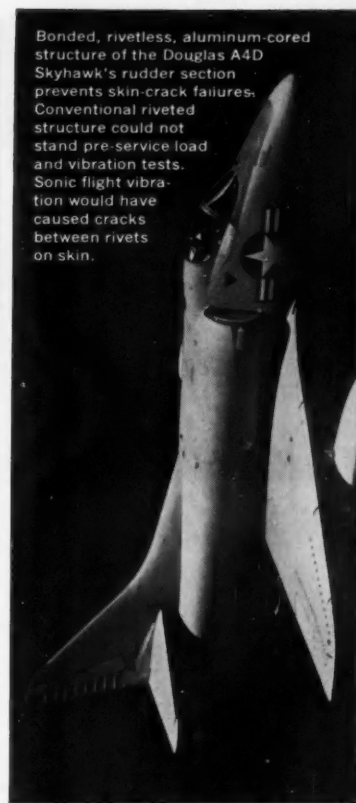


Photo courtesy Douglas Aircraft Company, Inc.

11 Ways *Ray-BOND* Adhesives Solve Tough Fastening Problems

New bonding and laminating techniques at R/M help solve difficult fastening problems and thereby make possible many of the new products being developed and produced by America's advancing technology. The advantages of Ray-BOND adhesives include:

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Counsel and detailed technical information regarding the selection and application of adhesives are freely available to you from Raybestos-Manhattan. An R/M representative can call on you promptly to discuss your requirements.

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Please send me a free copy of your new technical Bulletin No. 701.		
Name _____		Title _____
Firm _____		
Address _____		
City _____		State _____

Briefs of SAE PAPERS

continued from page 131

ated by vehicle; measuring philosophy, equipment characteristics, and test procedures; characteristics of interference meter consisting of receiver, indicator, calibrator, and signal pickup device; requirements for receiver; details of impulse generator; method of measuring broadband interference; reference made to measuring set Model NF-105, built by Empire Devices, Inc., Amsterdam, N. Y., for range from 14 kc to 1000 Mc; operation and advantages.

Vehicle Design Considerations to Meet Suppression Objectives, L. J. VANDERBERG. Paper No. 315C. Se-

rious source of radio interference is caused by vehicle ignition system; methods of suppressing interference and basic techniques for reduction of interference relating to resistance (ignition), bonding and shielding (body and chassis), and avoiding RF coupling; details of Ford SAE-vehicle radio interference measurement test facility, built to determine effectiveness of various suppression devices; conclusions made from data obtained in tests.

NUCLEAR ENERGY

Excavation With Nuclear Explosives, G. W. JOHNSON. Paper No. 301A. Practicability of large scale excavation projects using nuclear explosives; results of experience with nuclear and chemical explosives evaluated; Soviet Union has been using massive charges of chemical explosives for excavation purposes for several years; present status of experiments and future program including proposed nuclear excavation experiment at Cape Thompson. 32 refs.

Distribution of Radioactivity from Nuclear Excavation, R. E. BATZEL. Paper No. 301B. Sources of radioactivity from nuclear explosion are fission products and tritium which are direct products of nuclear reactions, and radioactivity induced in surrounding medium by neutrons which are byproducts of explosion; phases involved such as nature of surrounding medium, time temperature history, and time of venting of debris which determine distribution of radioactivity; fallout pattern calculated for proposed Chariot experiment.

Compact, Mobile, and Portable Nuclear Power Plants in Army Nuclear Power Program, M. A. ROSEN, C. W. MALLORY, R. A. SCHWARZ, L. F. WILLIAMS, Jr. Paper No. 308A. Projects include 2 operating stationary power plants, one stationary, 3 portable, and one mobile are under construction, and 2 portable and one mobile in various design stages, and 2 experimental installations; plants cover boiling water, pressurized water, and gas cooled reactors, and may include liquid metal or analog type of reactor; project designation system and details of each plant.

PRODUCTION

Assembly Operations at B. O. P. South Gate Plant, R. G. CARTER. Paper No. 316A. Buick-Oldsmobile Pontiac Assembly Div. assembles cars in six plants; California plant uses single line system to assemble Buick, Oldsmobile, and Pontiac cars, Buick Special, Oldsmobile F-85, and Pontiac Tempest; general operations and introduction of off-line door and decklid program; 1961 model change and steps taken to solve problems created by integration of new models, such as job spacing of conveyors, underbody welding and body weld line operation; material storage problems, etc.

FOR DEPENDABLE *All Weather* COOLING



Install **EUREKA** RADIATORS

Over 30 years of specialization and engineering research have produced a radiator and core proved dependable under all conditions.

- **ALL-COPPER CORES and TUBES** double-lock seamed give greater strength and eliminate danger of rusting
- 1-piece upper-and-lower-tank brass stampings for **POSITIVE PROTECTION FROM LEAKAGE AND VIBRATION . . .**
- Large tube area for **EFFICIENT COOLING IN ALL WEATHER**, all driving conditions . . .
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We Invite
**INQUIRIES
ON**
Complete Radiators
**FOR ALL
INDUSTRIAL
APPLICATIONS**

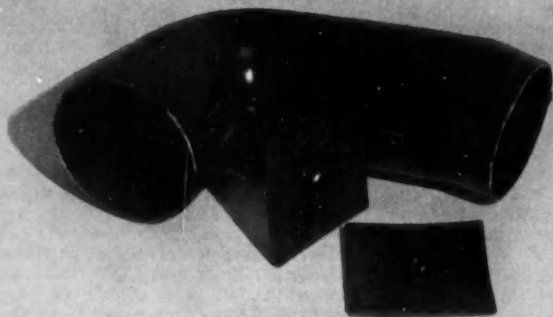


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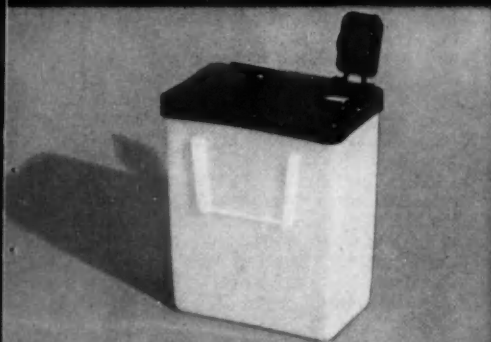
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Spring Silencers and Heater Duct—MARLEX silencers are durable, self-lubricating, and less costly. Duct is flexible, rot-proof, withstands tears and punctures.



Seat Side Shields—Cost less than painted steel ... dent and scuff resistant, lighter, easily cleaned, and with "molded in" texture and color.



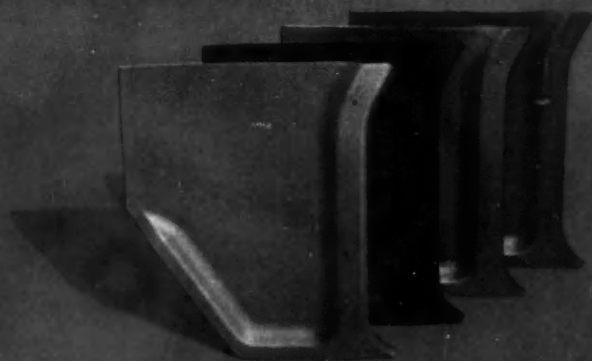
Windshield Washer Jar—Container made of MARLEX won't shatter or burst ... is unaffected by freezing or under-the-hood temperatures.

The MARLEX* look on 1961 cars

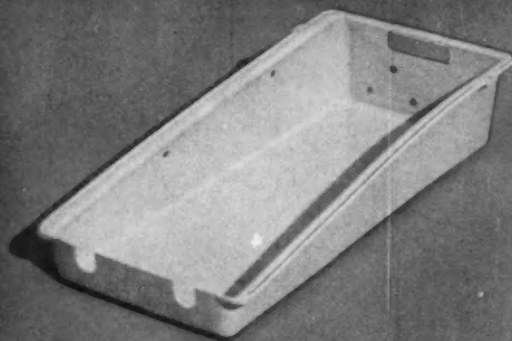
Shown here is a selection of current applications for MARLEX variously used by American Motors, Chrysler Corp., Ford, and GM. They offer new proof of the improved performance (at comparable or lower costs) provided by this versatile, high density plastic.

MARLEX items (like the original equipment applications shown here) are unaffected by extremes of temperature (-180°F to 250°F) and resistant to acids, alkalies, oil and grease. They are lightweight, tough, durable, non-allergenic, corrosion- and rot-proof... can be machined, welded, bolted, and printed upon. There are production advantages, too. Superior finished items can be quickly and economically produced from MARLEX high density resins by injection molding, extrusion, blow molding or thermoforming.

Technical and design data on MARLEX high density polyethylenes and ethylene copolymers, and their many uses, is available to you.



Side Cowl Panels—Colorful and textured MARLEX panels improve styling ... will not scuff, dent, or tear ... are color fast and easily cleaned.



Glove Compartment—Economical "quality upgrading" with MARLEX ... new box is rugged, functional, and longer lasting.

*MARLEX is a trademark for Phillips family of olefin polymers.

For more information, see your plastic fabricator... or contact us.

PHILLIPS CHEMICAL COMPANY

Bartlesville, Oklahoma

A subsidiary of Phillips Petroleum Company



New Members Qualified

These applicants qualified for admission to the Society between March 22, 1961 and April 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: Harold Albert Nelson (A), Glenn Henry Shire (M).

British Columbia Section: Michael Alan Cordner (J).

Central Illinois Section: Francis Alati George (J), James Arnet Hooker (J), Bobby Joe Orr (J), Harold V. Towles (M).

Chicago Section: Mathew J. Alagna (A), Clifford D. Brauck (M), Robert F. Davis (M), Jack W. Durham (A), Warren Jensen (J), Edmond William Kraft (M), Henry Andrew Leidecker (M), Ray F. Notz (M), Joel Arthur Pieper (A), Donald A. Piepho (J), Duane R. Smith (J), Harold R. Watson (M), Robert F. Wenger (M).

Cleveland Section: Arnold F. Buchholz

(J), Reynold Gamundi (M), Edward Emri Kish, Sr. (A), David E. Neustadt (A).

Colorado Group: Leland Price English (A).

Dayton Section: Russell G. Chandler (J), Robert John Parker (J), Ernst Hermann Ruf (J).

Detroit Section: Duncan C. Augustine (M), Dewey Ross Butt (M), Alan E. Carlson (A), Julius A. Chelenyak (A), Russell M. Cooper (M), Larry K. Drake (J), Thomas Stowe Eccles (A), Charles Albright Feeser (M), Jerome D. Freedman (M), Steven John Garbarino, Jr. (J), Fred A. Gluckson (J), Neil M. Goodwin (A), Edward T. Goulet, Jr. (J), Benjamin Willis Harrison (J), Gilbert J. Hensien (J), Leroy J. Herbon (M), Harold J. Holderness (M), David J. Jay (M), John W. Jorgenson (M), Dan W. Kaufeld, Jr. (M), Leo J. Kevitt (M), Jerry Martin Kovarik (M), A. David Laudani (M), J. E. Leidgen (M), Charles Mauch (M), William S. McDowell (M), Louis M. Millon (M), John McLay Murray (M), John R. O'Brien (M), Robert Victor Pautsch (J), Henry L. Petri (A), Darrell C. Richmond (J), Richard Emory Smith (A), Phillip Denis Smitley (A), William Sobkow, Jr. (J), Jack W. Spiroff (A), Mark J. Sturtevant (M), Walter T. Szymanski (J), Peter Vaicekauskas (M), Arthur R. VanSteelandt (M), William Lee Vaughn (J), Donald Beverly Wilson (A), Howard Oren Wold (J).

Fort Wayne Section: George Maxwell DeRoche (J), James C. Hoelle (M), Herbert Garth Mcken (A), Robert LaVerne Tordoff (J), James W. K. Ying (J).

Indiana Section: Dwight O. Crim (M), Charles T. Flatt (J), Beldon Lee Rich (M), John E. Storer, Jr. (M), Thomas Wendell Williams (A).

Metropolitan Section: Henry Larry Bungart (M), Gerald S. Fields (A), Frank Jannelli, Jr. (A), Edward O'Hearn Leahy, Jr. (A), Joseph Martorello (M), Edmond Norton Skinner (M), Serge Valin (A), Fred W. Wallsteiner (M).

Mid-Michigan Section: Earl L. Helmers (M), John B. Mason (J), Lawrence W. Moriarty (J), R. Michael Tucker (J).


Milwaukee Section: Donald H. Mathes (M), Timothy M. Seth (J).

Mohawk-Hudson Section: John C. Krambuhl (A).

Montreal Section: Thomas Edward Barff (M), Edward Henry Carroll (A), Lionel Kenneth Jones (A), Bernard Labelle (A), Jean Guy Moore (M), Robert Harry Wright (M).

New England Section: William P. Cox (A), Comdr. Grover King Gregory (M).

continued on page 139



• C A S T I N G S

"TECHNICAL POLICEMEN"
on patrol
every hour, every heat, every day

If you require *meticulous* precision in the metallurgical, chemical, and physical properties of your castings, you will find it here.


Customers tell us that our ability to maintain the most complex alloy specifications is so marked that we are often referred to as "the prescription counter foundry."

We specialize in small castings in high volume—alloyed gray and white irons, and high alloy steels. We invite inquiry.

Makers of important component castings for the automotive, aircraft, hydraulic, and special machine industries.

ENGINEERING CASTINGS, INC.
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Licensed Producers of Ni-Hard, Ni-Resist,
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*Rigid Radial Roller Suspension
by Mather . . . 1876 or so*

**LET
MATHER
SOLVE
YOUR
SUSPENSION
PROBLEMS,
TOO**

This masterpiece of engineering ingenuity* was fidgety but fast . . . owners everywhere proudly stated, "It Sho Con-go."

We're not too proud of this rustic rig but we are proud of the fact that, for over 50 years, our designers, engineers and manufacturing facilities have played such an important part in the advancement of automotive riding comfort.

If you have a suspension problem, or if you're interested in tapping our metal treating "know-how" . . . please call

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*The gravitational warp of the diametric transversal is directly opposed to proportionate conic force.







LEAD

**Youngstown leaded steels
increase your production,
prolong tool life**

Adding lead to steel is a Youngstown art, hard to learn. You add the right amount at the right time. Disperse it. Keep the content range correct. Check it, test it, inspect it, control it from the teeming floor to finished hot rolled and cold drawn bars.

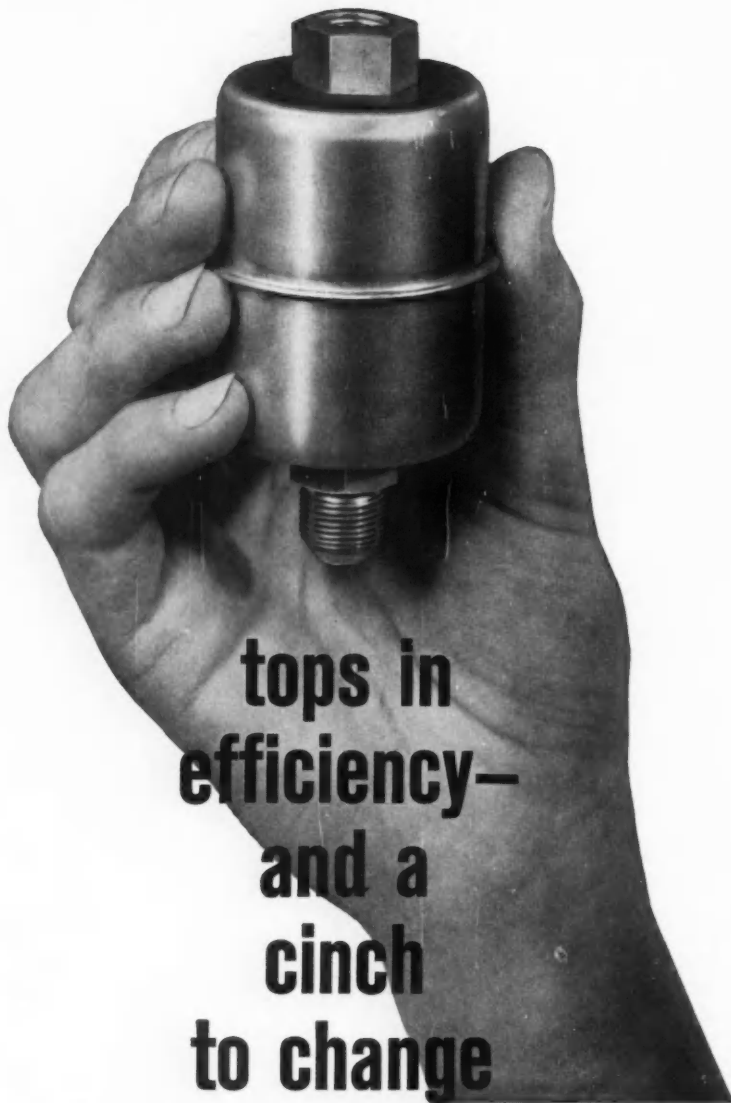
Youngstown Yolead and other leaded steels give you better machinability, longer tool life and faster cutting speed. You get more reliable performance, improved ductility. You get lower costs. From small carburetor fittings to big automotive forgings, Youngstown can provide the exact leaded grade that you need, when and where you need it.

Get all these advantages with leaded carbon and alloy steels from Youngstown. Get fast, dependable delivery from your Steel Service Center, and through 28 Youngstown offices. Get quality, get performance, get leaded steel from Youngstown who knows how to make lead behave inside steel.



Youngstown - growing force in steel

For more information about Youngstown leaded steel, write: Dept. 15-B
The Youngstown Sheet and Tube Company, Youngstown, Ohio



tops in efficiency— and a cinch to change

HERE'S ALL YOU DO! Unscrew the two fittings that join the Purolator GF-11 Filter to the fuel line. Throw away the dirty filter. Fasten in the replacement. Now you're ready for 5,000 miles of efficient, trouble-free fuel filtration. Total time involved? *Less than 5 minutes.*

MOTORS RUN SMOOTHER... Because this Micronic® filter removes dirt, metal, rust, scale and gum... even microscopic particles down to 5 microns.

ADAPTABLE TO ALL GASOLINE ENGINES. Purolator fuel filters like the GF-11 shown above, are standard equipment on most 1960 cars. However, it can be incorporated into the fuel system of almost *any* gasoline engine—automotive, portable or marine.

MORE ADVANTAGES. Easy installation and replacement is a big reason for the popularity of the Purolator GF-11 Fuel Filter. But here are more:

***PEAK EFFICIENCY.** Because Purolator replacement filters are inexpensive, and easily installed, chances are they'll be replaced at proper intervals—and *always work at peak efficiency.*

***LONGER SERVICE LIFE.** Because of the special pleated construction of the filtering unit, the GF-11 has fully *70 square inches* of filtering surface. It operates longer at peak efficiency.

***COMPACTNESS.** The GF-11 measures about 3" by 1½". It can be installed either horizontally or vertically.

***VERSATILITY.** The GF-11 Filter can be installed as an O. E. M. item on practically any gasoline-engine—from sport cars and garden tractors to power mowers and midget racers.

For complete information on the GF-11 and other Purolator filters, write to Purolator Products, Inc., Department 3849, Rahway, New Jersey.

Filtration
for Every
Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey, and Toronto, Ontario, Canada

New Members Qualified

continued from page 134

Northern California Section: Donald D. Collins (M), Frank James Helms (M), Joseph A. Rau (A).

Northwest Section: Harold Guy Edwards (A).

Ontario Section: Zigmund deGalocsy (M), George F. Howard (M), George William Jamieson (A), Norman Patrick Maycock (M), Thomas Patrick Monaghan (M), Douglas Albert Taberner (A), Walter James Woolidge (M).

Oregon Section: Martin Philip Davis (J).

Philadelphia Section: John Francis Clark (M).

Pittsburgh Section: James Milton Arnold (A).

San Diego Section: August S. Lermer (M), James Lewis Wainwright (M).

South Texas Section: Frank William Dillingham (J).

Southern California Section: James Bernis Bristol (J), Bo Nilsson Hoffstrom (M), Charles Lewis Landers (J), Robert Ray Myers (J), Jack Alfred Rassi (J), Ralph Henry Ruud (M), Duane Arnold Sanborn (J).

Southern New England Section: George Ducrow (A), Charles Francis Paquette (M).

Spokane-Intermountain Section: Robert H. Benesch (A).

Texas Section: John Carroll Boteler (A), J. A. Kerr (M).

Texas Gulf Coast Section: Hyman Dave Massin (M).

Twin City Section: John Forrest Anderson (M), Ambrose D. DeGidio (M).

Washington Section: Roy Albert Hoffman (M).

Western Michigan Section: Raymond J. Green (M).

Wichita Section: John Cope Borden (A), Richard P. Cover (J).

Williamsport Group: George William Daneker (J).

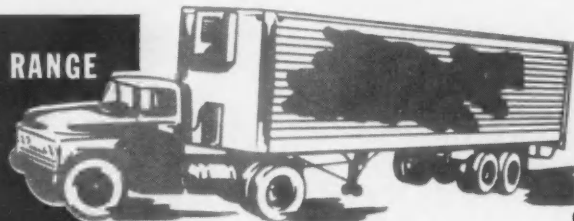
Outside Section Territory: Eugene Francis Chojnowski (M), Loy M. Clemmer (J), Carl George Fritz (M), John Robert Shepard (M).

Foreign: Krishan Lal Ahuja (J), India; William Doyne Chadwick (A), Australia; Edward Joseph Coucke (M), Belgium; Joseph T. Froehlich (M), West Indies; Ramon Guillen (J), Mexico.

continued on page 141

TRUCKERS ARE REPLACING ORIGINAL EQUIPMENT ENGINES WITH THE "PRECISE POWER" OF CONTINENTAL RED SEALS

A BROAD RANGE OF BASIC ENGINE MODELS



GASOLINE-DIESEL-LPG 26 TO 300 HORSEPOWER

The unmatched breadth and diversification of the Continental line of Red Seal transportation engines—listed here—assures PRECISE power for heavy-duty highway trucks and tractors, both as original equipment and as replacements for other makes, in buses, taxicabs, door-to-door delivery vehicles, transport mixers and the like.

6 East 45th Street, New York 17, New York • 6216 Cedar Springs Road, Dallas 35, Texas • 3402 Century Boulevard, Inglewood, California • 1252 Oakleigh Drive, East Point (Atlanta) Georgia

TRANSPORTATION GASOLINE ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
N4062	4	2 1/2	3 1/2	62	26.3 @ 3500 RPM
Y4069	4	2 1/2	3 1/2	69	28.0 @ 3400 RPM
Y4091	4	2 1/2	3 1/2	91	36.0 @ 3400 RPM
F4124	4	3	4 1/2	124	47.0 @ 3200 RPM
F4140	4	3 1/8	4 1/2	140	52.0 @ 3200 RPM
F4162	4	3 1/8	4 1/2	162	58.0 @ 3200 RPM
F6186	6	3	4 1/2	186	77.0 @ 3500 RPM
F6209	6	3 1/8	4 1/2	209	90.0 @ 3500 RPM
F6226	6	3 1/8	4 1/2	226	98.8 @ 3500 RPM
F6244	6	3 1/8	4 1/2	244	105.0 @ 3750 RPM
M6271	6	3 3/4	4 1/2	271	96.5 @ 3000 RPM
M6290	6	3 3/4	4 1/2	290	108.0 @ 3000 RPM
M6330	6	4	4 1/2	330	125.0 @ 3000 RPM
M6363	6	4	4 1/2	363	146.0 @ 3000 RPM
B6371	6	4 1/2	4 1/2	371	123.5 @ 3000 RPM
B6427	6	4 1/2	4 1/2	427	142.0 @ 3000 RPM
G4193	4	3 1/2	4 1/2	193	77.0 @ 3500 RPM
FO-6226	6	3 1/8	4 1/2	226	143.0 @ 4500 RPM
K6271	6	3 3/4	4 1/2	271	114.5 @ 3200 RPM
K6290	6	3 3/4	4 1/2	290	123.0 @ 3200 RPM
K6330	6	4	4 1/2	330	147.0 @ 3200 RPM
K6363	6	4	4 1/2	363	162.0 @ 3200 RPM
T6371	6	4 1/2	4 1/2	371	143.8 @ 3000 RPM
T6427	6	4 1/2	4 1/2	427	170.0 @ 3000 RPM
U6501	6	4 1/2	5 1/2	501	186.0 @ 2600 RPM
R6513	6	4 1/2	5 1/2	513	192.2 @ 2800 RPM
R6572	6	4 1/2	5 1/2	572	220.0 @ 2800 RPM
R6602	6	4 1/2	5 1/2	602	232.0 @ 2800 RPM
S6749	6	5 1/2	5 1/2	749	250.0 @ 2800 RPM
S6820	6	5 1/2	5 1/2	820	300.0 @ 2800 RPM
V8603	8	4 1/2	4 1/2	603	260.0 @ 3200 RPM

TRANSPORTATION DIESEL ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
GD4193	4	3 1/2	4 1/2	193	66.0 @ 2600 RPM
TD6427	6	4 1/2	4 1/2	427	146.5 @ 2600 RPM
RD6572	6	4 1/2	5 1/2	572	172.0 @ 2400 RPM
VD8603	8	4 1/2	4 1/2	603	200.0 @ 2800 RPM
SD6802	6	5 1/2	5 1/2	802	225.0 @ 2200 RPM

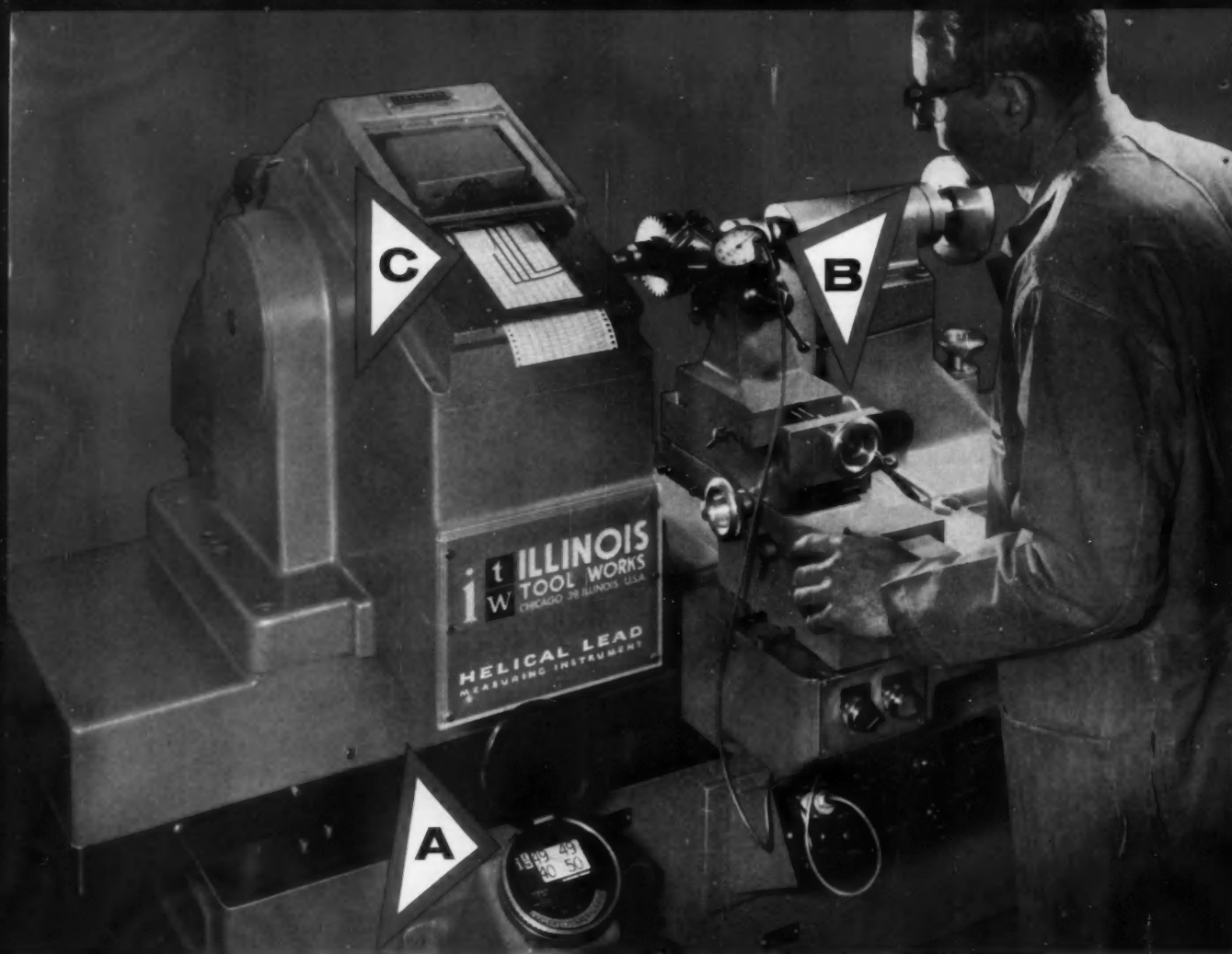
TRANSPORTATION LPG ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
K6271	6	3 3/4	4 1/2	271	115.0 @ 3200 RPM
K6330	6	4	4 1/2	330	145.2 @ 3200 RPM
K6363	6	4	4 1/2	363	154.0 @ 3200 RPM
T6427	6	4 1/2	4 1/2	427	166.0 @ 3000 RPM
U6501	6	4 1/2	5 1/2	501	176.5 @ 2600 RPM
R6513	6	4 1/2	5 1/2	513	170.0 @ 2600 RPM
R6572	6	4 1/2	5 1/2	572	200.0 @ 2600 RPM
R6602	6	4 1/2	5 1/2	602	210.0 @ 2600 RPM
S6749	6	5 1/2	5 1/2	749	246.0 @ 2600 RPM

Continental Motors Corporation

MUSKEGON • MICHIGAN





Check and Double Check — BETTER GEARS

This Helical Lead Measuring Instrument* checks and records within .0001" the helix angle on helical gears to assure that the position of the tooth bearing meets the print specifications.

This machine utilizes the optical principle of machine setting (A)

to measure accurately any angular deviations observed visually (B) and permanently recorded (C).

This is one of many details of gear manufacture and inspection that has won for DOUBLE DIAMOND gears their reputation as gears thoroughly qualified for top

performance in any application for which you buy them.

Our sales representatives are engineers and gear designers — ready to tackle a gear assignment at any stage of its development. When may one call on you?

Just write or phone.

**This model was introduced at the 1960 Machine Tool Exposition in Chicago.*

EATON

**AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA**



GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS



New Members Qualified

continued from page 139

ico; K. Harilal (J), So. India; Clayton A. Ildza (M), Argentina; Somasundram Kannan (J), So. India; Kasi Gopala Mohandas (J), India; John Allan Pankhurst (A), New Zealand; Darayes Norshirwan Pestonji (J), India; Adul Pinsuvana (J), Thailand; R. C. Rainsford (M), So. Australia; V. G. Rajagopalalan (J), So. India; Charles Allan James Ramsay (M), Australia; Nihal Chand Sehgal (J), India.

Applications Received

The applications for membership received between March 22, 1961 and April 22, 1961 are listed below.

Alberta Group: Delmer Charles Stitt, Ronald Ernest Wemp

British Columbia Section: Michael Russel Langford, D. G. Lenzen, Joseph Anthonius Vriend

Buffalo Section: Philip Fred Alessio, Donald Andrew Haase

Central Illinois Section: Richard C. Busby, Dempsey Woodrow Cochran, Norman John Glomski, Calvin David Loyd, Ralph E. Master, Richard Edward Maxwell, Robert Joseph Vogel

Chicago Section: Aldo Albert Ambrosini, Ernest Donald Anderson, Paul Aloysius Bauer, E. Eugene Bruning, Robert G. Diener, William Dennis Doyle, F. William Foss, John Andrew Goad, Paul R. Knestrict, John Milton Moran, Patrick Lee Powell, Stanley Walter Turner

Cincinnati Section: Richard Withrow MacKenzie, Gordon Meridith Rapier

Cleveland Section: Walter E. Boyce, Glenn Wilbur Carter, Joseph Gerald Casey, Lee D. Keefer, Loran Edwin Manning, Judson L. Phillips, Jr., Paul Eugene Pritchard, Eldridge William Rose, Lloyd E. Skinner, Donald E. Sykes, Gene David Wall

Colorado Section: Russell Eugene Faris, Sr., Robert Lee Morris, Richard A. Sharp

Dayton Section: Leslie V. Anderson, Howard C. Sunderman

Detroit Section: Bernard Adinoff, Samir Salim Amin, Thomas Harry Baylis, Jr., Joseph Gerald Bishop, Marvin S. Blemly, David Garrett Boone, Calvin W. Bowers, Jean Joel Cordier, Curtis Frank Durekrey, Gordon Duane Elliott, Myron Phenando Ellis, Donald Duane Ferm, J. Ernest Gross, Jr., Scott

David Harvey, Francis E. Heffner, John Alan Heppeler, Arthur William Hesskamp, Peter Kalil, Robert Hayes Knapp, Byron Warren Koch, Andrew Dean LeCocq, Richard Clemens Lins, Lloyd Herman Lippert, Charles Kenn Litzenberger, Richard J. Milliman, Frederick Stephen Murley, Michael C. Myal, William John Naples, Jr., Leo Edward Olbrys, Douglas Miles Patterson, Thomas Joseph Pavliscak, Allen Keith Peacock, Howard Dean Peacock, Donald Buell Pentecost, Joseph Benjamin Reineke, Donald Max Scriver, Lee J. Seymour, Albert E. Sickinger, Bert Kenneth Sisson, Emich Duane Solms, William F. Thomas, III, Joseph Frank Waughn, Norman Valentine Wiatr

Hawaii Section: James S. Ahern, E. Collins

Indiana Section: Louis Miller Brubaker, Robert Allen Cheetham, Harold Vernon Elliott, William Frederick Harrison, Rex Hoppes, Michael Francis King, Calvin S. Kunkle, Louis Joseph Raver, William Merton Scott, Clark Estill Sloan, Peter Michael Stroth

Kansas City Section: Jimmy Leroy Holladay

Metropolitan Section: T. Roland Berner, Lawrence W. Bierman, John Michael Csady, Howard Paul Cutson, Sven Arne Jones, Charles Krause,

Fort Wayne Section: Jon W. Dufendach, John Henry Evans, Charles W. Porter, Mark Sherbinsky, III

continued on page 142

GAS • OIL • ELECTRIC
DIRECT FIRED OR ATMOSPHERE CONTROLLED



*Production
Heat
Treating
Equipment*

FOR ANY OF THESE PROCESSES:

**ANNEALING • BRAZING • CARBURIZING
CARBO-NITRIDING • FORGING • CARBON-
RESTORATION • HARDENING • SINTERING •
FORGING • NORMALIZING • TEMPERING**



6545 EPWORTH BLVD. DETROIT 10, MICHIGAN
43 YEARS OF ENGINEERING LEADERSHIP

Applications Received

continued from page 141

Leonard Howard Lustbader, Kazimieras Kizlauskas, Gerald Richard Martas, Robert Wood Pringle, Robert Edward Stacy, Thomas Grandison Tousey

Mid-Continent Section: Tyrone Wayne Phillips

Mid-Michigan Section: Joginer N. Anand, James Marquis Lorang, James Russell Lovell, Joseph Leo Pohl,

Thomas R. Wiltse

Milwaukee Section: Robert Dibble, Paul William Freedy, Harvey Lynn Hoy, Rodney Anthony LeMense

Montreal Section: Fernand A. Belanger, Charles Henry Turner

New England Section: George Alfred Biron, Joseph Edward Dwyer, John Ward Harrison, David H. Robbins, Edward J. Splaine

Northern California Section: Roy Bear-dall, Kenneth Leroy Bergman, Robert Alan Escobar, William Henry Hoffman, George Semones Kent, Charles Evan

Lindblad, James Richard Mathers, Arthur Stoneman Pedrick, Gerald Lyle Shreve, Gray Eugene Wilson

Northwest Section: Richard Edwin Gregg, Raymond Howard Rockstead, Fred E. Wing

Ontario Section: Steve Vdoviak, Jr.

Oregon Section: Raymond Wayne Kreman, Carl W. Sermuks

Philadelphia Section: Raymon R. Brunner, Robert L. Thomason, Leonard Lyle Tipton, Jr.

Pittsburgh Section: Ray E. Bonassi, Eber W. Gaylord, William Donald Lion, Robert Earl Quigley, Nicholas Joseph Scheid, Jr.

Saint Louis Section: George R. Baumgartner, Edgar Bertel, Robert Edward Buser, David Edward Taylor

Salt Lake Group: John Jacob Brunner, Yu-Hsin Chao, Clayton Stewart Miller

San Diego Section: Howard Oliver Earl, William L. Johnston

Southern California Section: Russell Daniel Barnes, Jr., Lawrence James DeYoung, Thomas Lee Fidler, John Edmund Harrell, Fred J. Hone, Patrick John Imbriano, Keith L. Mackie, Sidney Anthony Mackin, William Douglas McBride, Ronald Robert Mealhow, Jim Lee Mosman, James Parry Oakes, George Gustav Wald, James Donald Watson, John Edwin Winkler, William Roy Wodell

Southern New England Section: Benjamin Lewis Hochman

Syracuse Section: William Joseph Beall

Texas Section: Ernest Victor Bunata, Grady Gilder, Jr., Bobby Ray Harms

Texas Gulf Coast Section: Wayne Hugo Cave

Twin City Section: John Joseph Kelly, Edgar M. Resel

Washington Section: Norman Bennett, Nelsen M. Cook, Jr., Maurice Herbert Wright

Outside Section Territory: Jule Joseph Baudhuin, Clifford James Beam, Ralph Norman Binkley, Robert Thomas Harnsberger, Jerry Ross Hochstatter, Nathaniel Dare Lamberson, Jack Alton Roach, Victor V. Sharpe, Jr., Allen LeRoy Summers, Walter Hammond Wiley, III

Foreign: R. C. Banga, India; Lunazzi Elio, Argentina; Miroslav Hanke, Czechoslovakia; David Hodkin, England; Aurelio Lampredi, Italy; Luis Zamora Meneses, Mexico; Robert Racine Pereira, Brazil; Charles Grant Slinn, Canada; Kenneth Charles Thompson, South Africa



You can depend on PALNUT fasteners to meet every specification—every shipment. PALNUTS are precision-produced in huge volume at low cost—inspected at every step of production.

You can depend on PALNUT deliveries, too. High-capacity facilities, large stocks, plus systematic follow-thru at our Detroit office and warehouse, as well as the home plant, keep shipments moving on schedule.

Are you making fullest use of PALNUT fasteners? There are many styles, in a wide variety of finishes, including 3M Mechanical Zinc to meet the most rigorous salt spray tests. Call in a PALNUT fastening engineer—or write for catalogs.

THE PALNUT COMPANY

70 Glen Road, Mountainside, N. J.
DIVISION OF UNITED-CARR FASTENER CORPORATION
District Office:
730 W. Eight Mile Rd., Detroit 20, Mich.



LOCK NUTS and FASTENERS



Above: Detroit office and warehouse.

Left: Big, modern plant at Mountainside, N. J.

—every
PALNUT®
FASTENER
is
Dependably Uniform

RIGID QUALITY CONTROL ASSURES

- uniform dimensions
- uniform spring tension
- uniform assembly characteristics
- uniform plating and finishing
- uniform locking action



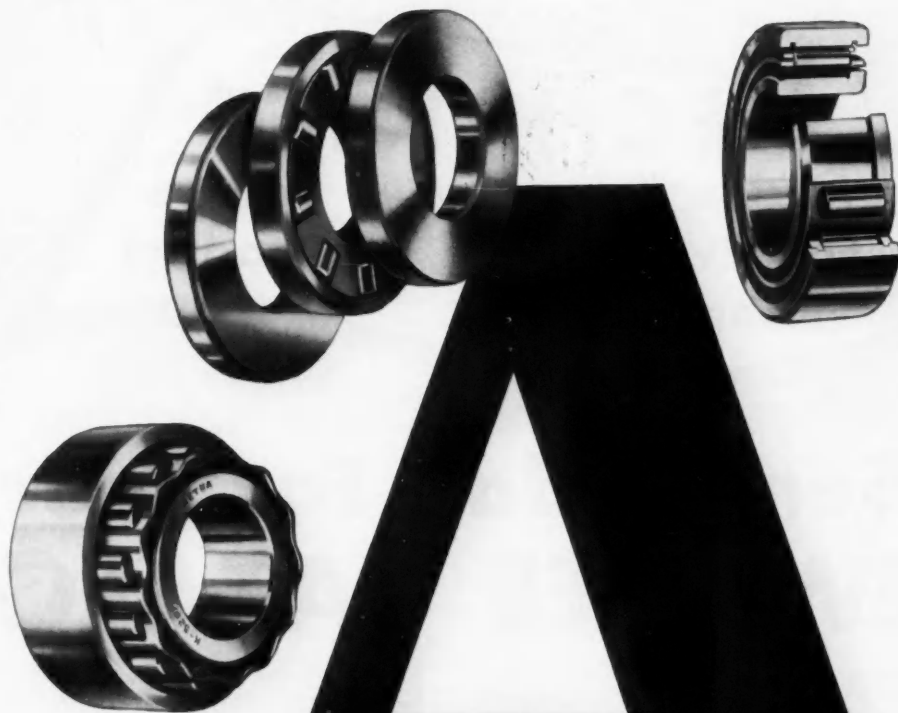
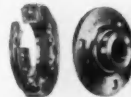
THERE'S MUSCLE IN AETNA ROLLER BEARINGS Aetna roller bearings offer an increased load capacity of more than 25%* over conventional roller bearings. This extra muscle is created by Aetna's exclusive True Crowned roller design. In this design, ordinary high stress points are eliminated, and the load is distributed across the full length of the roller for greater efficiency. True Crowning is an example of our advanced technology, which consistently provides you with more dependable bearing performance. Aetna roller bearings are available in a wide range of self-contained, pure radial, standard designs, and in many specials of both pure radial and pure thrust design. For details call your Aetna representative listed in your classified directory, or write for General Catalog and Engineering Manual.

*Determined by AFBMA formula

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Make *Roller Bearing* Joints
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MECHANICS

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BORO-WARNER

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.



for Strength

. . . Economy

. . . Versatility

Flame-Hardening Alloy Steels

The process known as flame-hardening involves the direct application of flame to the surface of steel, heating it above the transformation range, then hardening it by quenching. The primary purpose of this process is to achieve surface-hardness without affecting core properties. Jets of flame are played directly on the steel, and hardness penetration can be made to vary considerably. In alloy steels this depth will range usually from 0.03 to 0.12 in., the actual figure depending upon the method of heating and quenching used.

Unlike carburizing, flame-hardening does not involve the absorption of extraneous elements by the steel. There is no alteration of the chemical composition. To put it simply, the steel must have its own self-hardening characteristics; it cannot be dependent upon carbonaceous salt baths, gases, and other media.

Flame-hardening is not a substitute for the conventional furnace method. Each has its uses. The particular virtue of flame-hardening is that the flames can be directed to localized areas. The furnace, on the other hand, is generally more economical and feasible when parts produced in large quantities must be hardened all over.

Any type of hardenable steel, alloy or carbon, can be flame-hard-

ened, and there will usually be no scale or pitting. The alloy content is the governing factor when determining the quench. In some cases a rapid quench is required; in others, it can be as slow as air-cooling. Tempering presents no problems, for flame-hardened steel can be tempered as if hardened to the same degree by other methods.

A list of typical flame-hardened parts includes such familiar items as gear and sprocket teeth, and certain types of cams and rollers, and shoe treads. A complete list would include many other parts that often require a localized hardening treatment, especially for wear-resistance.

When you need information about flame-hardening methods, please feel free to consult with our technical staff. Bethlehem metallurgists will work with you, at no obligation, and you can depend on their suggestions. You can rely on Bethlehem, too, as a source of alloy steels . . . for Bethlehem makes the complete range of AISI standard grades, as well as special-analysis steels, and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

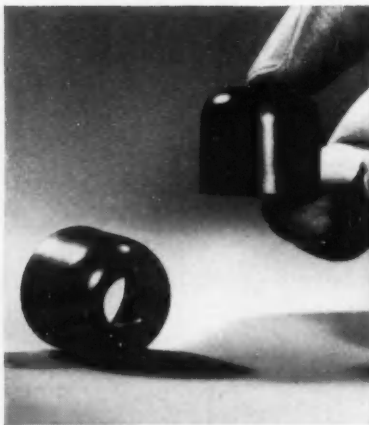


HOW YOU CAN HANDLE TODAY'S HIGH-OCTANE FUELS AND E-P LUBRICANTS

DU PONT VITON® SYNTHETIC RUBBER MEETS THE NEED FOR HEAT AND FLUID RESISTANT SEALS, TUBING AND DIAPHRAGMS



VITON RESISTS AROMATIC FLUIDS A major manufacturer of truck carburetors found that the increased aromatic content of gasoline caused rapid failure of the synthetic rubber piston cups in the accelerating pump. He replaced the pump cups with new ones made of VITON and solved the problem.



VITON RESISTS HOT LUBRICATING OIL Valve stem seals of VITON are in regular commercial use in a line of heavy-duty truck engines. After 150,000 miles an engine was dismantled and parts inspected. VITON seals showed virtually no wear, maintained good oil control despite high temperatures.



VITON RESISTS EXTREME HEAT A leading aircraft manufacturer needed a firewall material that would stay flexible and serviceable at 500° F. Asbestos, coated with VITON, provided the solution. This VITON fire seal resists jet fumes, ozone, corona, withstands the heat and vibration generated by Mach 2 speeds.

Du Pont VITON combines outstanding heat resistance (up to 400° F. in continuous service; 600° F. intermittently) with excellent resistance to hydraulic fluids, aromatic fuels and extreme pressure lubricants. Result: a new design material with a wide range of automotive and aircraft applications.

VITON, in contact with extreme heat and a wide variety of fuels and lubricants, is dimensionally stable—has low compression set, high modulus, good tensile strength—is available in a hardness range from 60-90 Shore A durometer. In addition

to these mechanical properties, it is also resistant to flame, ozone, age and weather.

VITON, a new versatile design material, is often the only elastomer that will stand up in service when hot fluids are involved. Present and potential uses include valve stem seals, carburetor pump cups, transmission front pump seals, rear axle pinion seals, power steering hose tubes and heat-resistant coated fabrics. Ask your rubber goods supplier about VITON, or write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE-6, Wilmington 98, Delaware.



VITON®
SYNTHETIC RUBBER

Better Things for Better Living . . . through Chemistry



Ross Model S10 steering . . . 8:12:8 variable ratio, 2.1 turns lock to lock. Aluminum components.

I have Ross variable-ratio steering, too!

Ross

"With automotive-type steering, my golf car maneuvers like a sports car.

"And since it has a Ross *variable-ratio* gear, I get faster steering and quicker recovery for turns, and slower steering and greater stability for straight-ahead handling. Much *steadier* and *safer* for hilly terrain!" Ross makes a gear for every steering need—manual or power, constant or variable ratio. Ross invites *your* inquiry.

STEERING

ROSS GEAR & TOOL COMPANY, INC.
Ross Division, Lafayette, Indiana • Gemmer Division, Detroit, Michigan



Here's where nickel steels give "Payhauler"[®] extra strength for hustling 27-ton loads

When this beauty roars out of the quarry with 27 tons of rock on its back, you can be sure its gears and shafts encounter brutal shock-loads and torsional stresses.

International Harvester engineers anticipated this rugged service at the design stage, took logical steps to give the "Payhauler" extra stamina:

They specified a variety of vital power-train components in heat-treated nickel alloy steels, case hardened to Rockwell "C" 60 min. for wear resistance, and at the same time providing high core properties for resistance to extreme loads, fatigue and shock.

For transmission gears, and other critical parts that take heaviest impact and compressive stresses, they chose AISI 4817 (3½% Nickel). Made from this steel, gears and pinions handle highest tooth loads, resist spalling, take impact in stride.

For components that meet all but the severest loading and abrasion, the I-H designers selected carburizing grade nickel alloy steels of the AISI 4300 series for the best combination of case and core properties. Carburized AISI 4300 steels (containing 1.85% Nickel) are used for the spiral bevel ring gear,

differential pinions and side gears, transmission shafts, and integral axle and sun gear.

When you design, order, or use heavily stressed components of trucks or construction equipment, remember that nickel alloy steels take the tough jobs in stride. The new 76-page booklet, "Nickel Alloy Steels... in Engineering Construction Machinery" is packed with valuable engineering information. Write for a free copy. ®Reg. T.M., International Harvester Co.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street  New York 5, N. Y.

INCO NICKEL
NICKEL MAKES STEEL PERFORM BETTER LONGER



CRUEL TURNS, RAW SPEED—VICTORY RIDES ON ROLLER BEARINGS!

This pit stop is for tires, gasoline, *but no repairs!* Winning the race against time and keen competition demands peak performance from every mechanical component . . . no matter how violent the torture. Roller bearings, for instance, must perform so well they can be taken for granted. This is a familiar challenge for Bower engineers. Their many original contributions to roller bearing design have helped improve

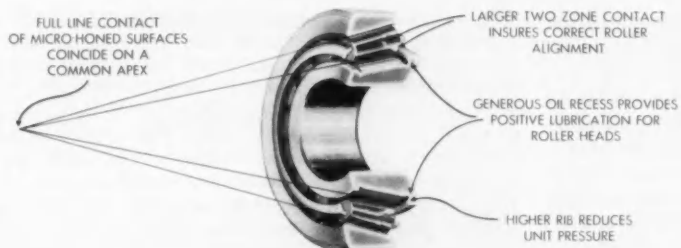
performance, minimize maintenance and reduce bearing failure to a rarity. That's why Bower Roller Bearings are widely used by the automotive and practically every other type of industry. If your product uses bearings, select from Bower's complete line of cylindrical, tapered and journal roller bearings. For technical assistance, write Bower Roller Bearing Division, Detroit 14, Michigan.

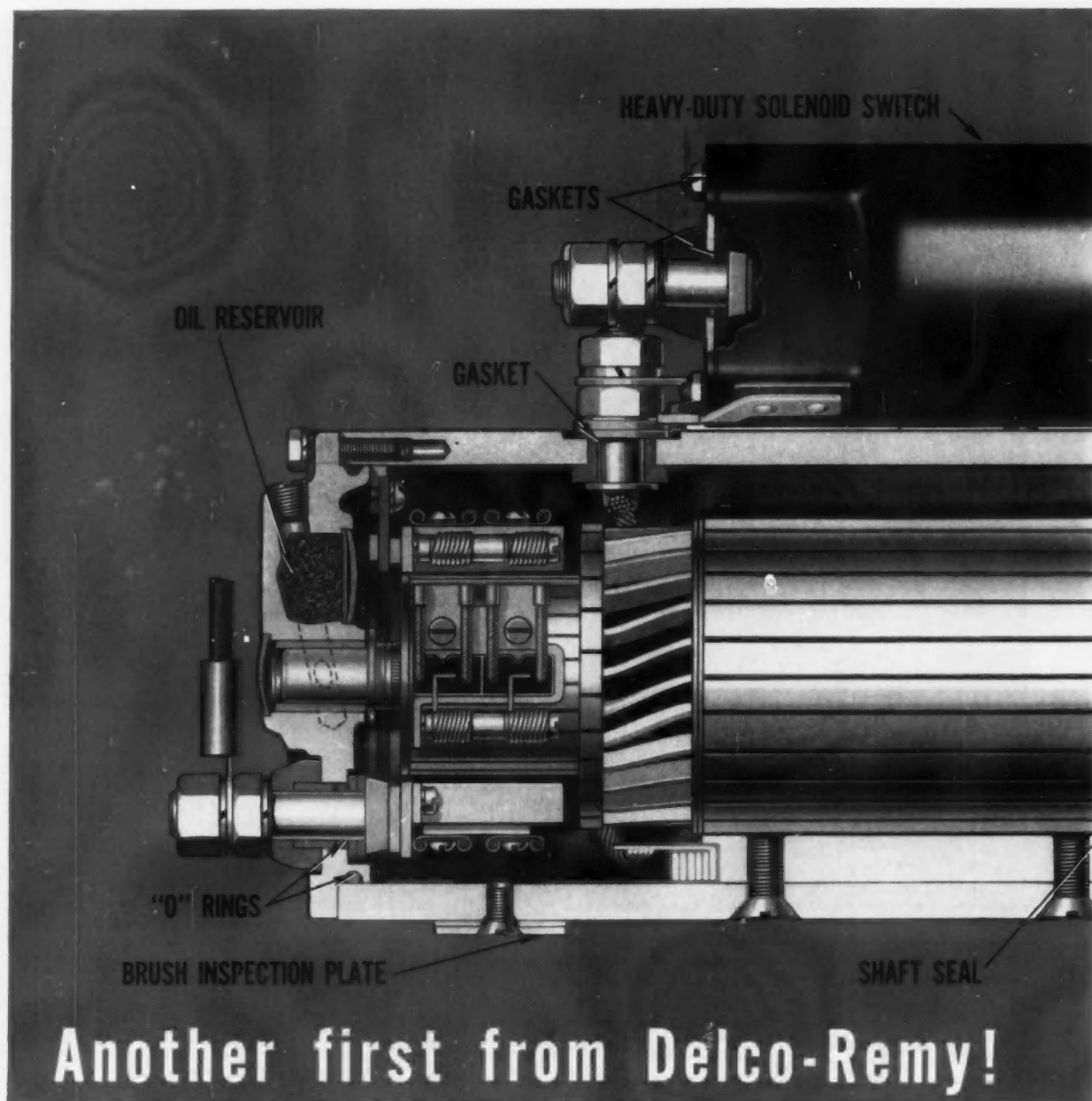
BOWER
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DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

IMPROVED DESIGN INSURES TOP ROLLER BEARING PERFORMANCE





Another first from Delco-Remy!

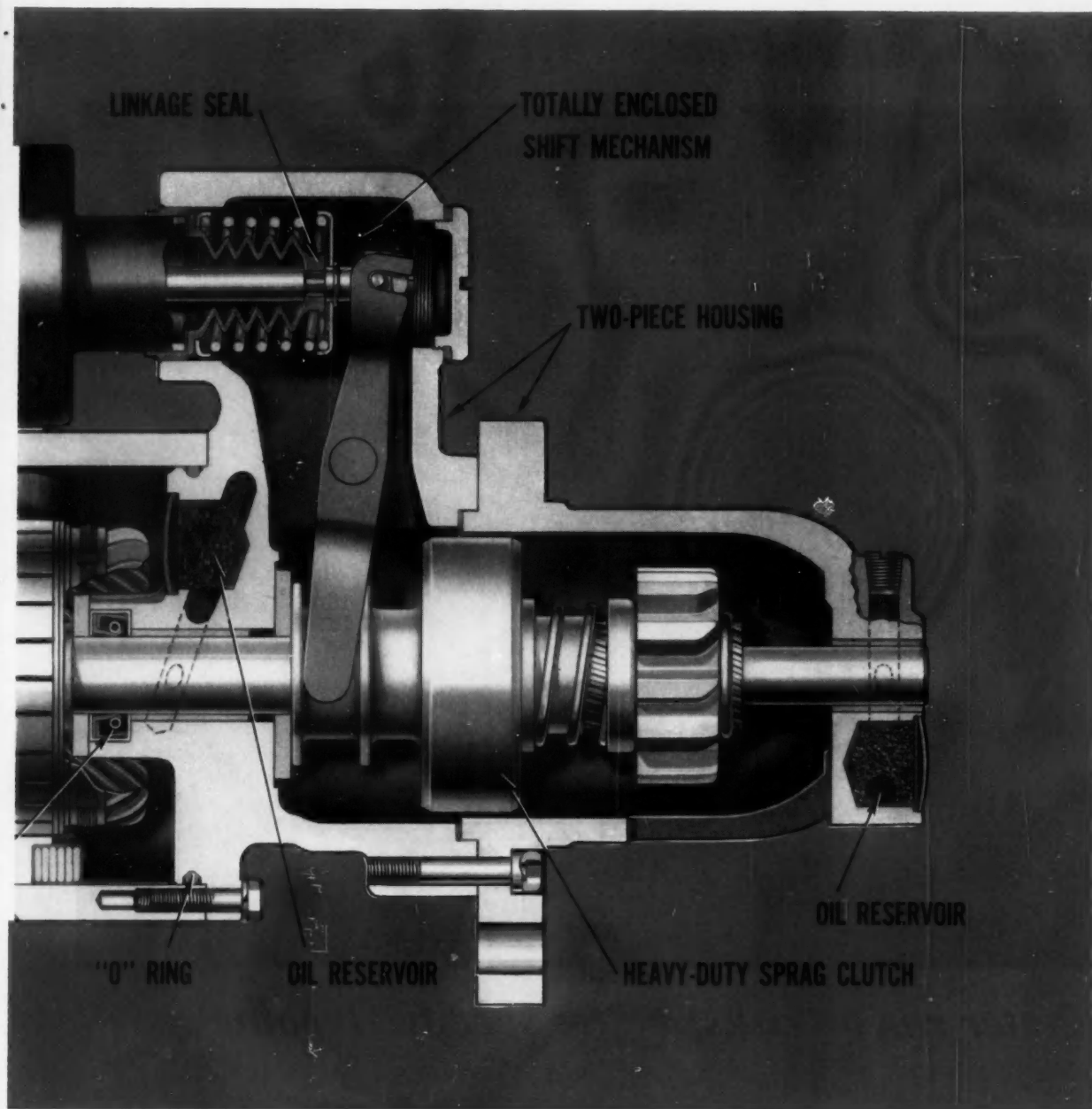
NEW DELCO-REMY HIGH-OUTPUT MOTOR

Completely new series of high-output cranking motors! These 12-volt motors have the torque and speed to do the same job as 24-volt motors of equal size and on the same battery power. No need for series-parallel switches and their complicated wiring on engines up to 900 cubic inches. These solenoid-operated, over-running clutch type heavy-duty cranking motors come with special two-piece drive housings that permit 24 different motor mounting positions. Their new 50% longer brushes, together with sealing rings (optional) and large oil reservoirs (optional), assure extra-long operating time between overhauls.

TOTALLY ENCLOSED DRIVE SHIFTING MECHANISM is protected against dirt, water, slush and ice. This enclosure, plus the shaft seal and linkage seal, also blocks transmission oil leakage into the motor and solenoid.

TWO-PIECE DRIVE HOUSING DESIGN permits 24 different solenoid positions which allows greater standardization—cuts fleet inventories. Nose housings are available in S.A.E. #2 and #3 mountings.

HEAVY-DUTY SOLENOID AND SWITCH provide positive pinion engagement and safely handle maximum starting current. Special seals keep out foreign material and allow increased contact life.



ELIMINATES SERIES-PARALLEL SWITCHES

SPRAG CLUTCH DRIVE operates with non-chamfered ring gear. Pinion indexes on spiral spline, positively engaging ring gear before power is switched on. Engagement of the pinion and ring gear is maintained during intermittent or sporadic engine firing.

HEAVY BRUSH INSPECTION PLATES resist damage from use and handling—are sealed to prevent leakage.

Engine manufacturers are invited to write directly to Delco-Remy for complete information and engineering assistance on the specific application of these new motors.

Fleet owners should specify this motor for new trucks through their truck dealers.

FROM THE HIGHWAY TO THE STARS

Delco-Remy
electrical systems



DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, IND.

"And now the pistons."



Better run no risks; better specify Hepolite...

PISTONS • PINS
RINGS • LINERS



for Hepolite pistons, pins, piston rings and cylinder liners are the finest available in the world. They are as reliable and economical in operation as man can make them, and they are manufactured by a huge precision engineering enterprise, whose experience goes back to the dawn of the motor industry."

The first law of engine economics!

HEPWORTH & GRANDAGE LIMITED • BRADFORD 4 ENGLAND Telephone 29595.

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135,000,000

BENDIX STARTER DRIVES



Leadership year after year after year

Bendix® starter drives have always set the standard for dependability in the automotive industry. They have been chosen for millions of installations in automotive vehicles, alone. Similar preference exists in other fields: the manufacturers of aircraft, earth movers, inboard and outboard marine engines have elected Bendix the number-one starter drive. For sure starts, equip your internal combustion engines with Bendix starter drives!

DEALERS—FOR MAXIMUM PROFIT AND SERVICE
SATISFACTION, USE ALL-NEW BENDIX STARTER DRIVES.



Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, N. Y.

What's News in Additives...



CONTROLLED CAR TESTS ON PARADYNE 101 using the mileage accumulation dynamometer.

NEW PARADYNE® 101

AN IMPROVED GASOLINE ADDITIVE FOR MODIFYING COMBUSTION DEPOSITS

Enjay Paradyne 101 is an improved combustion-deposit modifier which minimizes troublesome combustion chamber deposits. It reduces spark plug misfiring, surface ignition noise and rumble — and does it without increasing spark-knock octane requirement beyond what is normally encountered in a leaded gasoline containing no phosphorous.

ADVANTAGES TO REFINERS:

- Paradyne 101 gives better spark-

knock performance than conventional phosphorous-containing additives —and can either increase car satisfaction without additional cost, or maintain the same level of satisfaction at less cost.

- Paradyne 101 has no detrimental effect on gasoline road octane performance. In effect, it can provide *extra octane numbers*.

- Water contact will not extract Paradyne 101.

- Paradyne 101 is completely compatible in finished gasolines with other commonly used additives.

Outstanding performance of Paradyne 101 was proved in fleet test studies using late model cars.

For our new file folder containing complete performance data, call or write to your nearest Enjay office, or to 15 West 51st Street, New York 19, New York.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY





The RIGHT Insert for the Specific Application is Always the Most Economical

For heavy duty service involving extreme wear, corrosion, and oxidation, the highest performance high-alloy seat insert that can be produced is almost certain to be the most economical. On the other hand, for light duty service, a low cost insert of low alloy content may be adequate for the requirements. Eaton produces seat inserts "custom tailored" to meet the demands of each specific application — skillfully blends chromium, nickel, molybdenum, tungsten, cobalt, and iron to provide the right properties to overcome wear, corrosion, and oxidation. The result is inserts which will give optimum life at lowest cost, in the kind of service for which they are designed.

*Call our engineers for a consultation
on your seat insert problems.*

EATON

SAGINAW DIVISION
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN



DESIGN NOTES

C/R offers new bonded CRS Seal design in standard sizes — without premium tooling charges



CRS



CRSH



CRS-A



CRSH-A



Design Advantages

The CRS Seal now provides a new level of C/R Seal performance through its simple, bonded design. There are no internal parts to misalign, no avenues for internal leakage. The shell and sealing member are integral — bonded securely for the long life of the seal. The CRS Seal incorporates a sealing member with both improved lip configuration and improved concentricity. The sealing member has been strengthened over former designs by placing more material at points of major flex and wear — and without increased shaft loading.

Designer Advantages

The CRS Seal gives the designer one, basic, rugged shaft seal design which may be applied with high reliability to the great majority of common shaft seal applications — particularly in industrial, automotive, farm, and off-the-road equipment.

Four basic design variations are available. As you can see, these provide an auxiliary sealing lip, where it may be required, or provide extra rugged shell construction where conditions suggest the need to protect the seal lip against assembly damage — or where large, heavy-duty shafts are being sealed.

Selection of the new C/R Type CRS Seal gives the designer and buyer major advantages over special seals: shorter lead time on orders, simpler specification, savings in time and money, and improved assembly quality and reliability.

Operating Maximums*

Shaft Speeds	3600 fpm (single lip) 2500 fpm (double lip)
Run-out	.015" TIR dynamic eccentricity .010" static eccentricity
Temperature	—30 to +275°F. (225°F. in EP lube)
Pressure	5 psi (single lip) 10 psi (double lip)
Media	Oil, grease, fuel, water

*Not all conditions present in one application

New, Improved Compound

Standard sealing members for the C/R Type CRS Seal are molded of a new Sirvane synthetic rubber compound having markedly superior sealing and wearing properties. It is a Buna-N-based material with low-friction characteristics. The CRS Seal can also be furnished in the usual special materials such as acrylates, Sili-

cones, and butyls. Shells are of standard steel, but can be provided in corrosion-resistant materials on special order.

Consult C/R Engineers

For assistance on the application of the new CRS — or on any oil seal problem, get in touch with C/R Oil Seal Engineers. They're specialists in fluid sealing — and will gladly cooperate with you.

For More Design Data:

You will want the complete design data on the new CRS Seal. Write for our Bulletin CRS-100. It gives you the complete list of standard sizes, widths, O.D.'s, shell thicknesses and sealing lip heights. You will want it to compare and then specify C/R's CRS Seal.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1243 Elston Avenue • Chicago 22, Illinois

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In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd.,
Brantford, Ontario

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Great Neck, New York

DELCO'S 2N174 PROVED IN MINUTEMAN

... and Polaris and Talos and Atlas and Jupiter and Thor and Titan and Bomarc and Zeus and Pershing and hundreds of other military and industrial applications.

For Delco Radio's highly versatile family of 2N174 power transistors meet or exceed the most rigid electrical and extreme environmental requirements.

Over the past five years since Delco first designed its 2N174, no transistor has undergone a more intensive testing program both in the laboratory and in use, in applications from mockups for commercial use to missiles for the military. And today, as always, no Delco 2N174 leaves our laboratories without passing at least a dozen electrical tests and as many environmental tests before and after aging.

This 200 per cent testing, combined with five years of refinements in the manufacturing process, enables us to mass produce these highly reliable PNP germanium transistors with consistent uniformity. And we can supply them to you quickly in any quantity at a low price.

For complete information or applications assistance on the Military and Industrial 2N174's or other application-proved Delco transistors, just write or call our nearest sales office.

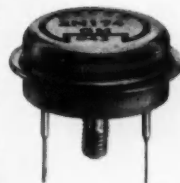
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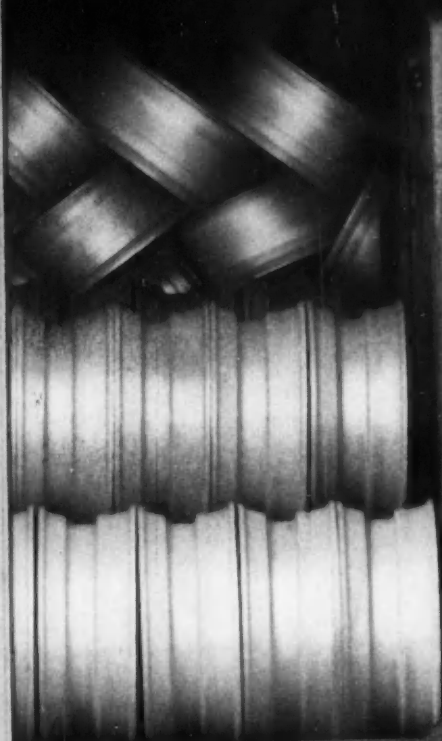
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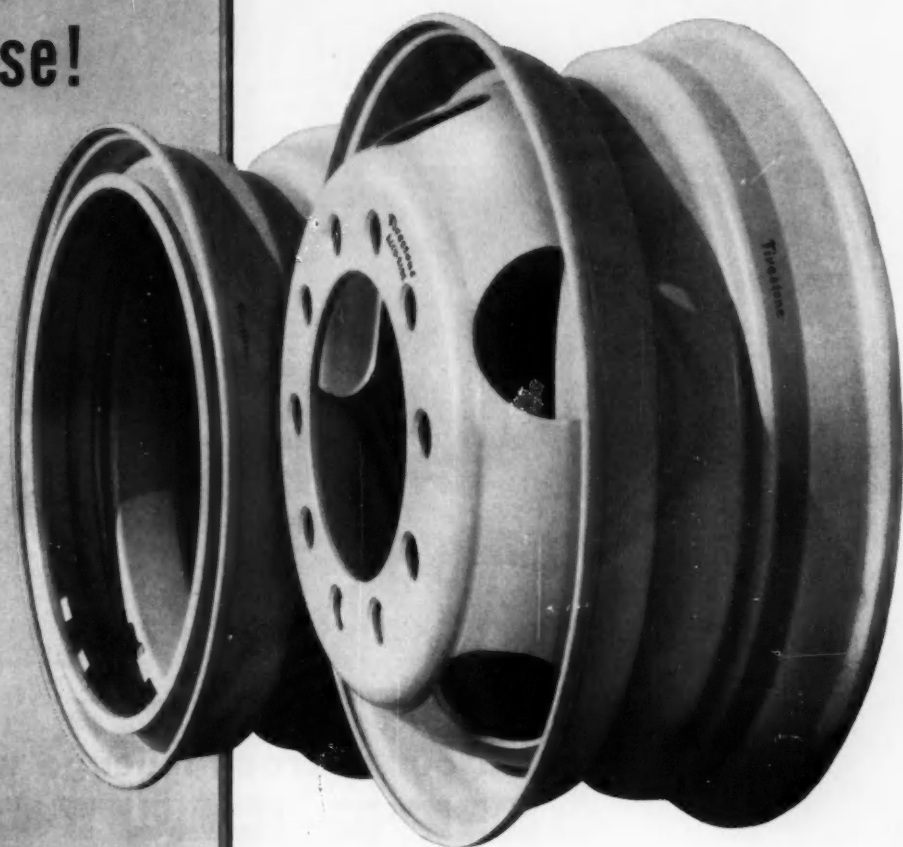


DELCO
DEPENDABILITY
RADIO
RELIABILITY

**Who builds
the world's
roundest, truest
wheels and rims
for every truck,
trailer and bus
on the road?**



Firestone, of course!



Firestone brings you the only complete line of steel wheels and rims on the market . . . the only line designed, engineered, tested and produced under one roof! And Firestone rims and wheels are backed by 52 years of manufacturing experience. Here are more reasons why they're your best bet for replacements and new equipment too:

Perfectly balanced ACCU-RIDE® WHEELS AND RIMS

- Cut wheel bounce and wobble
- Seal out rust and corrosion
- Provide extra strength
- Boost payloads.
- Roll truer
- Protect tires
- Give extra tire miles

Here's how Accu-Ride Wheels cut wheel bounce and wobble to give extra tire miles.



For new engineering and test data on Firestone Wheels and Rims, write Dept. 45(5).

Firestone

STEEL PRODUCTS COMPANY, AKRON 1, OHIO
INTEGRITY, QUALITY, ACCURACY, DEPENDABILITY

Copyright 1961. The Firestone Tire & Rubber Company



SCHOOLWAY  **TRANSPORTATION CO., INC.** says

"We doubled our average mileage with **LIPE CLUTCHES**"

"In our type of operation, our 90 buses average 28 to 30 stops per hour picking up children in traffic," says R. H. Paradise, president of Schoolway Transportation, Hales Corners, Wisconsin.

"Our average clutch life under this type of operation has been 20,000 miles. Our first Lipe Clutch was pulled at 39,000 miles — almost double our fleet average."

Like fleets of all types, Schoolway is interested in fundamental cost and performance: Unit cost. Re-

liability. Number of engagements between teardowns. Total mileage. Cost of labor and replacement. Loss of equipment use.

To these basic considerations Lipe Clutches give the answers: Longer equipment use. More engagements between teardowns. More total mileage. Lower average cost per mile.

These answers show up in fleet cost-analyses everywhere. They tell why, the Country over . . .

the trend is to LIPE!



There is a Lipe Clutch to meet requirements of vehicles 18,000 lbs. G.V.W. and up; for torque capacities from 200 to 3000 ft. lbs. For application assistance and specific data, contact the Company direct.





With a high speed of production - we produce
500 piston rings per minute - at the same time
maintaining fully controlled precision as a prime
feature of our work.

Goetzwerke
Friedrich Goetze AG
Burscheid bei Köln
Western Germany

minute
particles
of lead...



improve surface finish

On these center aligning balls used in automotive universal joints, CHARLESTON METAL PRODUCTS switched from A.I.S.I. 52100 to the same grade of steel *lead*ed.* They now report improved surface finish . . . a 15% increase in tool life . . . more uniform tolerances in finished parts. They also note that wear and shock resistance are not affected and uniform high hardness (RC 62-63) is maintained. Distortion remains at a minimum.


Results like these are not at all unusual when users switch to free-machining Aristoloy lead-treated steels.

For complete information about Aristoloy *electric furnace* bars and billets—call your local Copperweld representative or write today.

*Inland Ledloy License



DIVISION OF
COPPERWELD
STEEL COMPANY

ARISTOLOY STEEL DIVISION  4035 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.



Contributing to the miracle of modern car manufacture **SEALED POWER FACILITIES AND INGENUITY**

Because modern car manufacture is so vastly complex, it is easy to overlook the operational scope of many of the industry's individual purveyors. The manufacture of piston rings which match your engineering requirements, for example, is an involved and costly process.

Yet, as important at Sealed Power as ring production and quality control, are the men and the facilities which so often allow us to come up with independent

solutions to some of your knotty problems.

No one can top Sealed Power in service. To maintain this superiority, Sealed Power recently opened the piston ring industry's newest and finest research and technical center.

Historically Sealed Power has walked hand in hand with the reciprocating engine industry on the pathways of progress. We continue to dedicate all our abilities to our common cause.



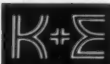
Progress through Profits

Sealed Power Preferred Performance

PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • SEALING RINGS FOR ALL APPLICATIONS

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE • 7-236 GENERAL MOTORS BUILDING • PHONE TRINITY 1-3440

Some Ideas



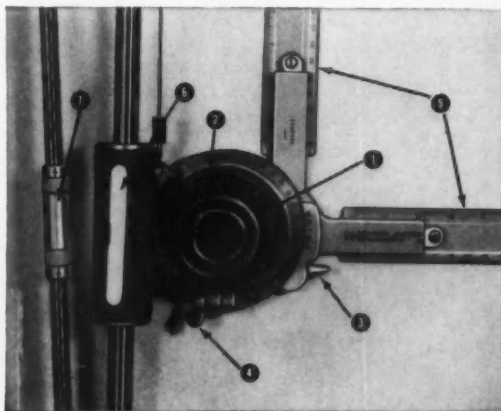
for your file of practical information on
drafting and reproduction from

KEUFFEL & ESSER CO.

Anything you can do with a drafting machine you can do almost as well with a T-square, triangle and protractor. It just takes a *lot* longer and it's a *lot* harder. That's why so few drawing boards these days are seen "sans-machine."

Every board — and draftsman behind it — has slightly different requirements. This is why there are PARAGON® Drafting Machines by K&E in a variety of tested styles. Just take your pick:

Whatever your angle...

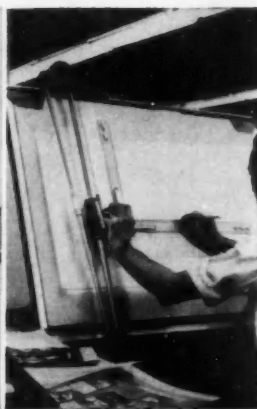


1. Full 360° indexing with automatic 15° stops, released at a touch. 2. Contour-designed control knob to match shape and motions of the hand. 3. Thumb-release to set in-between angles. 4. Base-line release — located near protractor head for fastest operation. 5. Easily-adjusted, interchangeable scales. 6. Conveniently placed finger-tip brake control to lock or release vertical position. 7. Convenient horizontal motion brake for one-hand operation, sitting or standing.

The PARAGON AUTO-FLOW® Drafting Machine is tops — by far the most versatile drafting machine to come along in years. A track-type machine with a wealth of work-saving features, the AUTO-FLOW can simplify your whole drafting operation. The board angle *you* find most convenient will suit the AUTO-FLOW to a "T." And no irksome counterbalance weights or friction brakes are necessary. A quick adjustment of a tension spring wheel puts the AUTO-FLOW in perfect balance — vertically, or anywhere down to the horizontal. The AUTO-FLOW's scales can be moved quickly and locked firmly into *any* position on the board. Both horizontal and vertical motion brakes are designed for rapid, one-hand operation. Smooth, *full-board* action lets you draw straight lines the entire length and width of the board in one continuous motion — something it's impossible to do with conventional machines. And — the *piece de resistance* — the AUTO-FLOW's superbly functional designs puts *all* controls conveniently on, or adjacent to the control head for the easiest operation ever. This engineered control system considerably reduces the number of arm and hand motions needed to produce a finished drawing.

Taking a page out of school...

A lot of firms employ chalkboards for group work, demonstration, rough planning, and other forms of "communal" drafting activity. If you've got such a board around your shop, we've got just the machine to fit it. Called the "Chalkboard" AUTO-FLOW this is essentially an AUTO-FLOW with elongated horizontal and vertical tracks and special mounting brackets. Whatever the length or height of your chalkboard, there's a Chalkboard AUTO-FLOW to accommodate it.



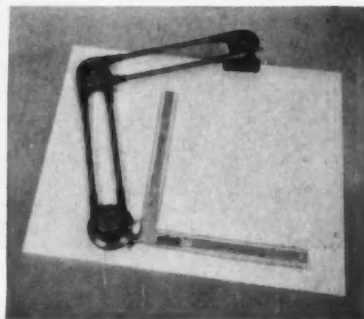
An old dog with new tricks...

If you prefer the conventional, "elbow-armed" drafting machine, the PARAGON standard is just your dish. You'll find plenty of refinements here, too. This is *one* "elbow-armed" machine that won't creep or crawl on the board. Just a twist of a thumb screw adjusts for perfect arm balance at any board angle up to 10°. The arms themselves *never* need adjusting. Tension bands are factory-set for years of use. Scales always lie snug and flat on the board and both arms twist freely in either direction. They can be lifted over objects on the board and returned to the same setting with ease. Baselines can be changed

instantly, too. A convenient release lets you establish a new baseline in seconds, while maintaining your "0" setting on the protractor. And the PARAGON standard has essentially the same engineered control head that so many swear by on the PARAGON AUTO-FLOW — the biggest time-saver in drafting since paper.

For the sometime user...

Maybe you're a design engineer, a chief draftsman, an ex-draftsman "keeping his hand in," or any one of many having only occasional need for a drafting machine. If so, the PARAGON Jr.® (shown below) is your mate. Originally designed for desk use by students, the PARAGON Jr. is ideal for the "part-time" draftsman. Patterned after the PARAGON standard, this compact drafting machine offers all the important features found in its full-sized counterpart, *plus* the convenience of "tuck-away" dimensions. Its combination mounting bracket permits temporary or permanent mounting on almost any desk, board, or table. It will operate efficiently at any board angle up to 25° and will accept any scales with standard chuck plates. Its engineered control head has full 360° indexing with automatic 15° stops, a convenient lock-lever for intermediate settings, and a rapid release for full 360° base-line adjustment while retaining "0" indexing.



And that's the lot — a PARAGON, we hope, for everyone. If the ease and speed of "feather-touch" drafting has a place in your operation, simply fill out and mail the coupon below and we'll show you how the PARAGON of your choice delivers it — like no other drafting machine can.

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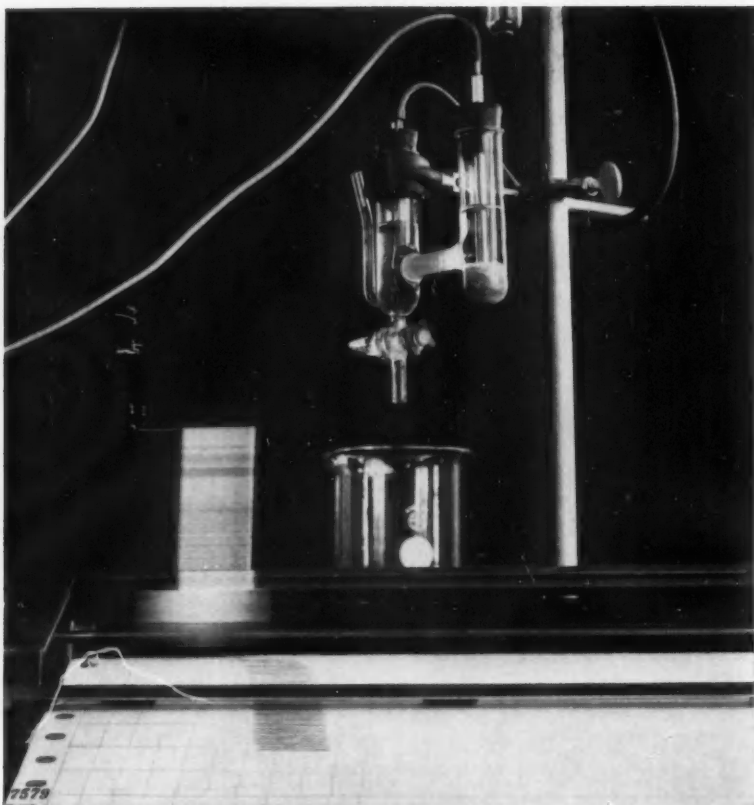
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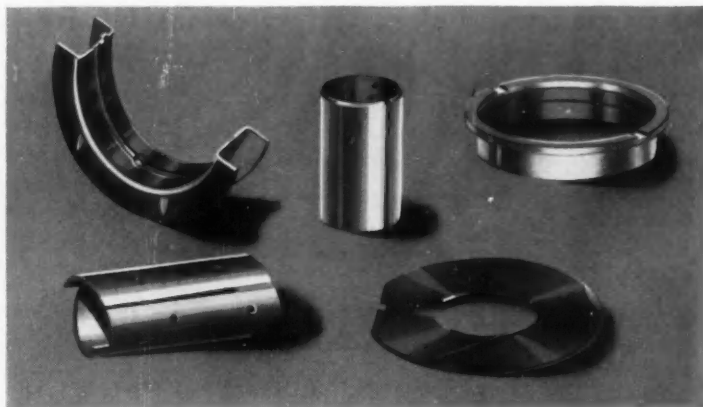


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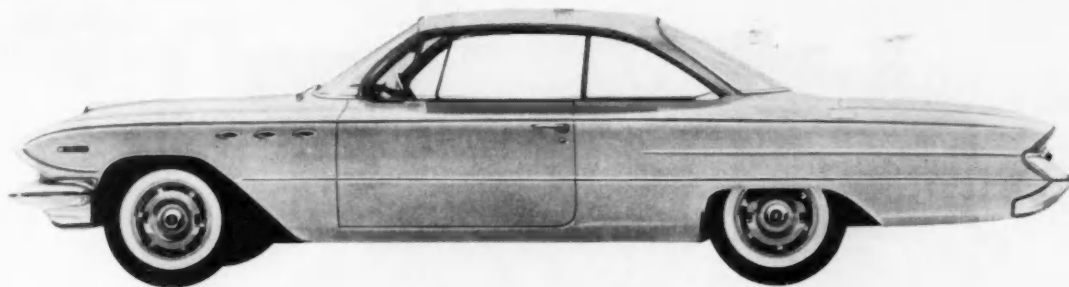


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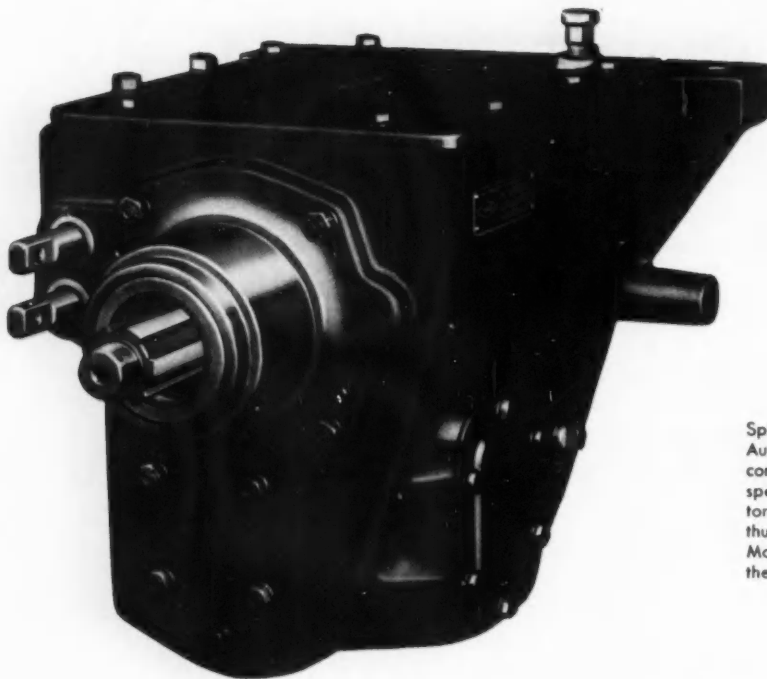


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New Spicer 4-Speed Auxiliary Transmission For Engines in the 400-600 Ft. Lbs. Torque Range

Model 7041 Broadens Range of Spicer Line, Utilizes Maximum H.P., Is Quiet, Saves Weight

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The result is that it is possible to utilize the maximum horsepower of the engine during shifts. In addition, the driver is able to complete shifts in these three splitter gear positions at the same R.P.M.

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For complete data on the many advantages of the new Spicer 7041, write to Dana Corporation, Toledo 1, Ohio.



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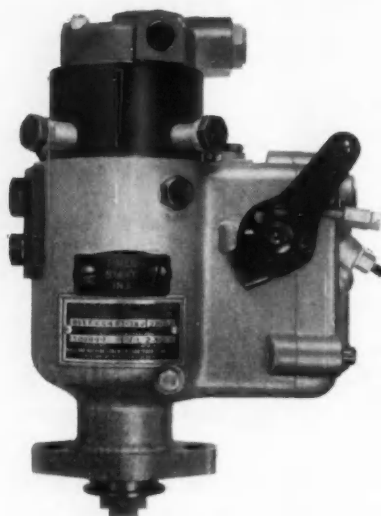
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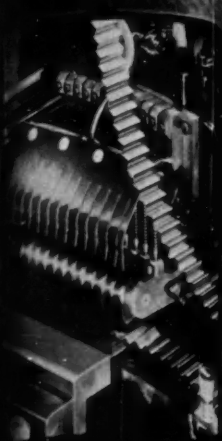
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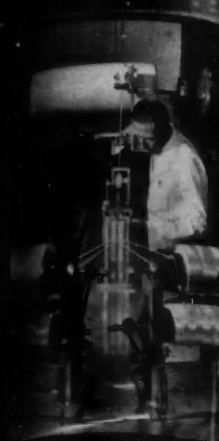
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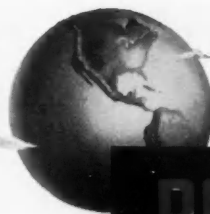
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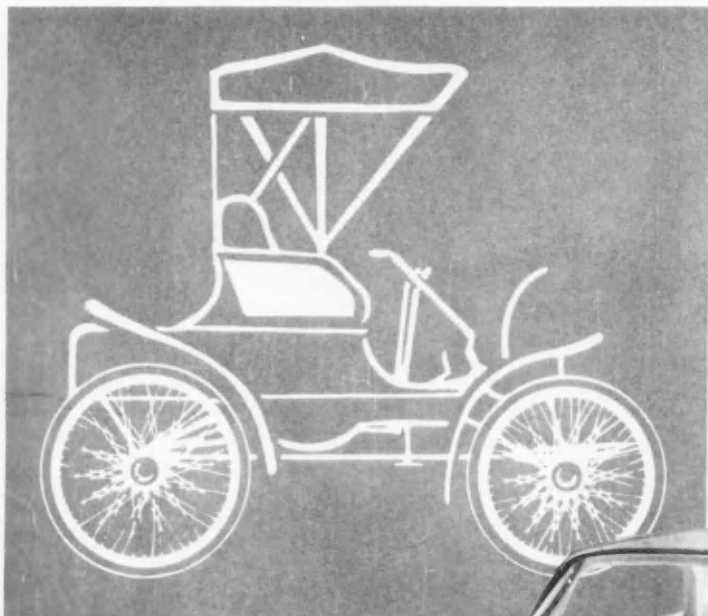
Main Plant and Headquarters: Chula Vista, California / Plant: Riverside, California / Assembly Plants: Winder, Georgia; Auburn, Washington



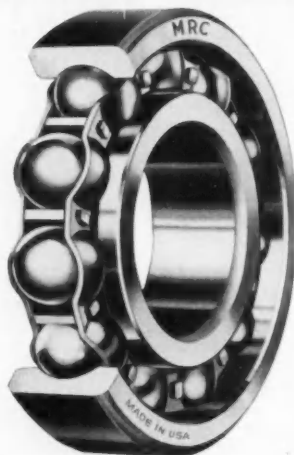
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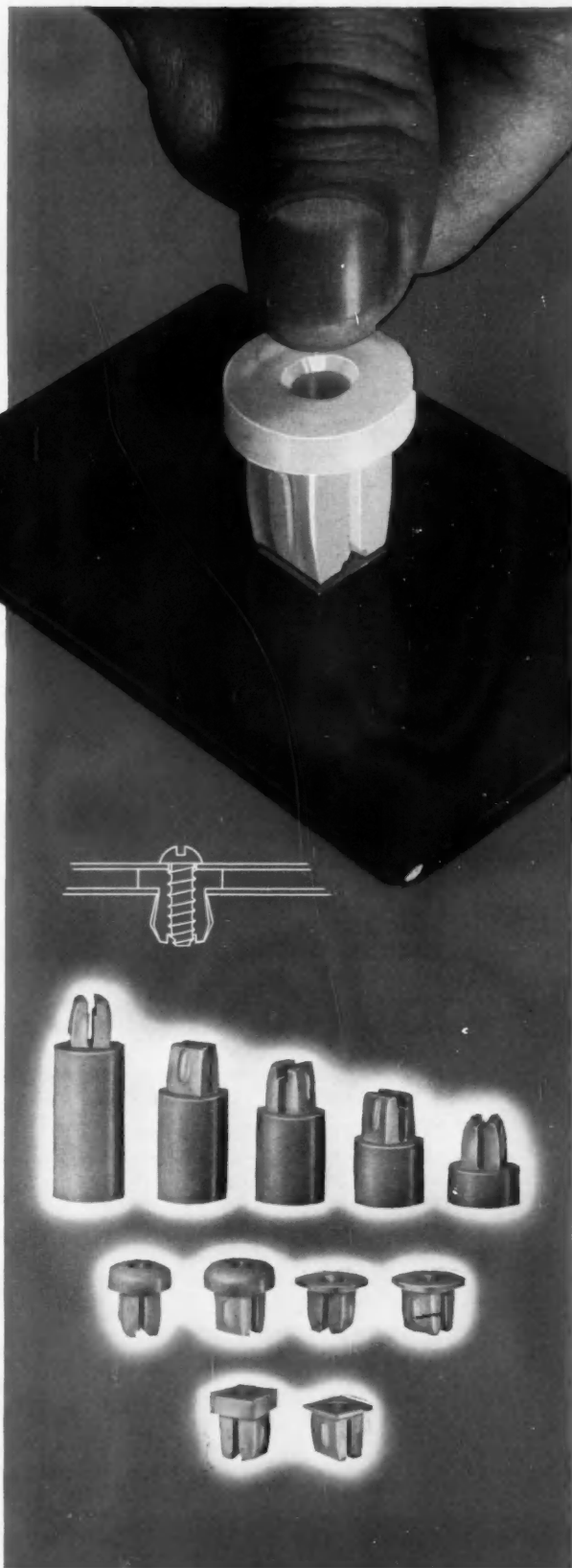
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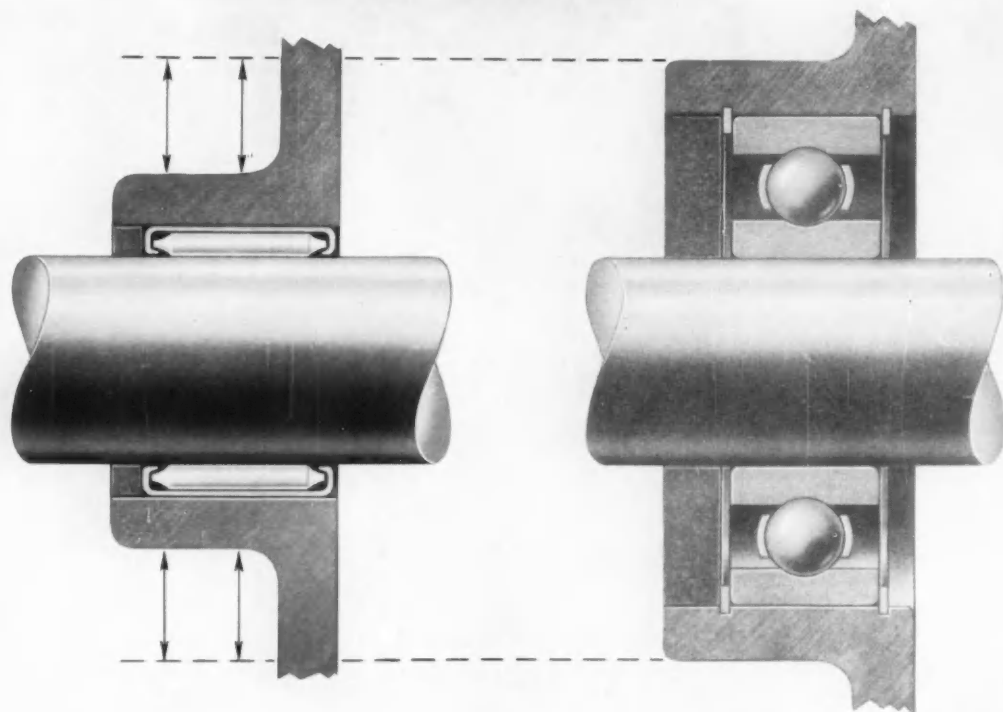
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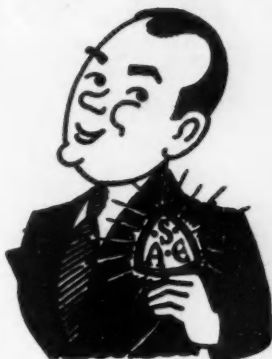
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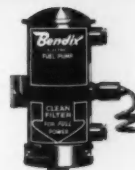
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TANDEM AXLE

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DOLLAR-MAKING TRUCK PERFORMANCE
EVER TO HIT THE HIGHWAY!**

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You've got to *drive* it—to really believe it! Here's an exclusive Eaton *3-Speed* Tandem Axle that is a revolutionary new approach to obtaining 15 gear speeds with only a 5-Speed transmission—an important big step forward in modern truck design!

Truckers can now, more than ever before, "turn" the engine to its maximum efficiency—keep it there effortlessly—at *any* road speed—on the hills—in traffic or out! No other gear combination can maintain as high an average speed with such ease—as can this amazing new *Eaton 3-Speed Tandem Axle*.

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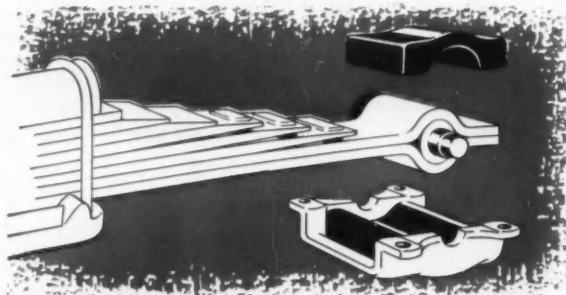
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Eaton Tandem Axles are also available in 2-Speed, Single Reduction, and Double Reduction types. Fast service if needed—85% of the parts in Eaton 3-Speed Tandem Axles are interchangeable with the famous Eaton 2-Speed single axle.

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5
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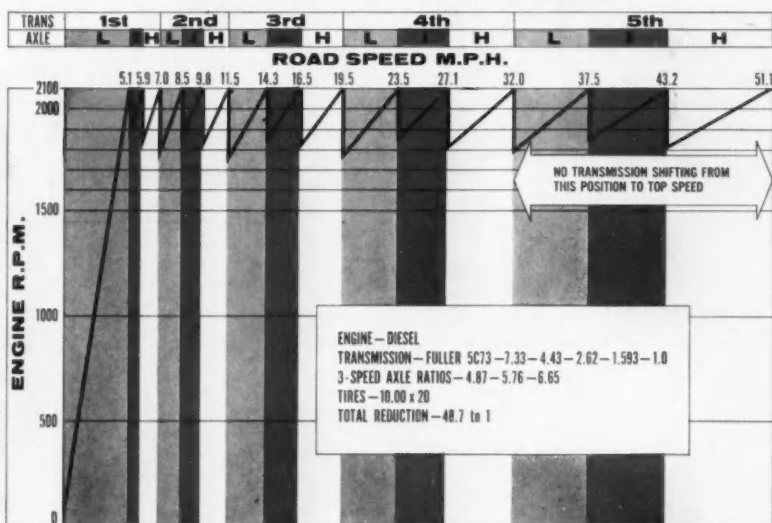


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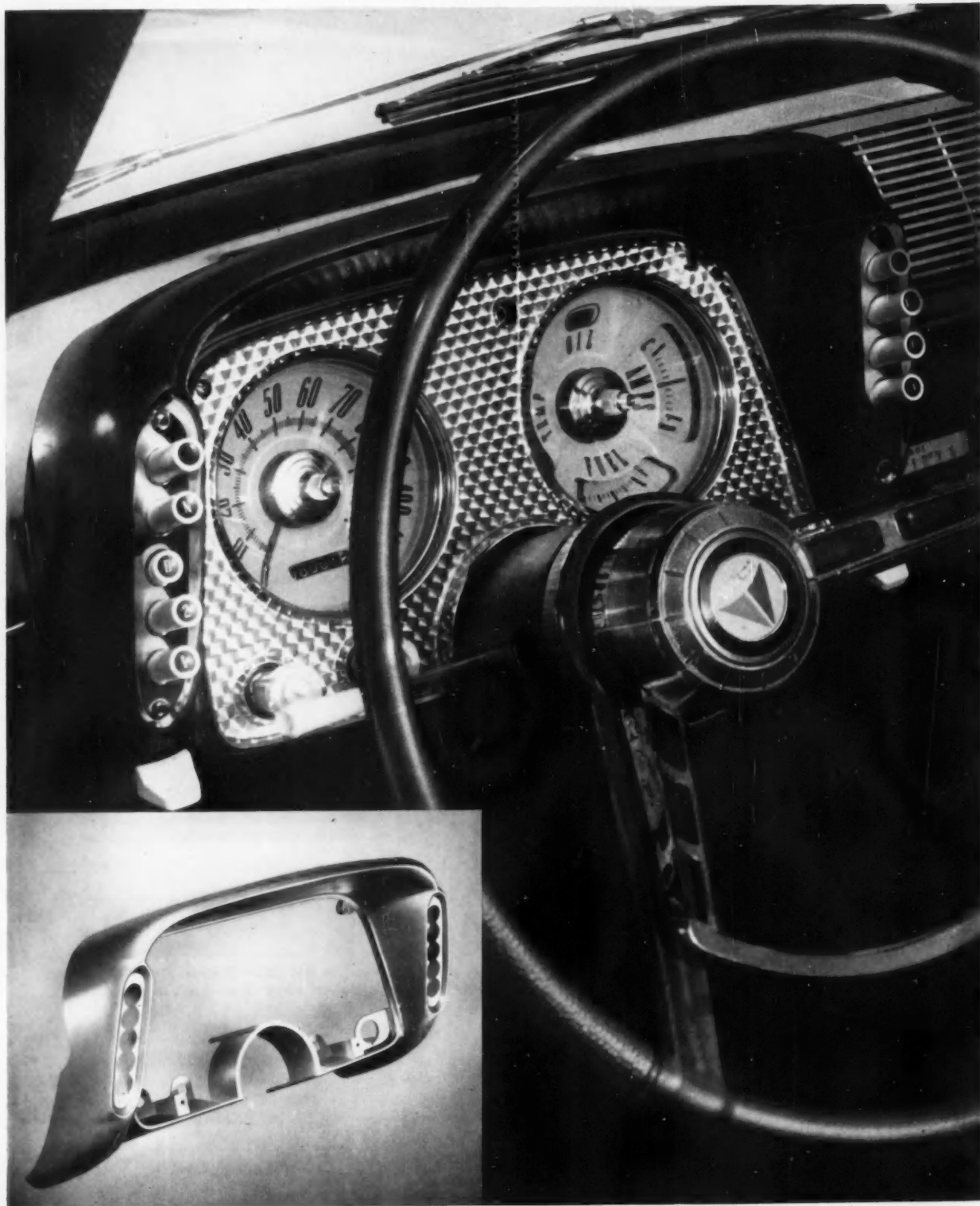
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GEAR SHIFT PATTERN CHART



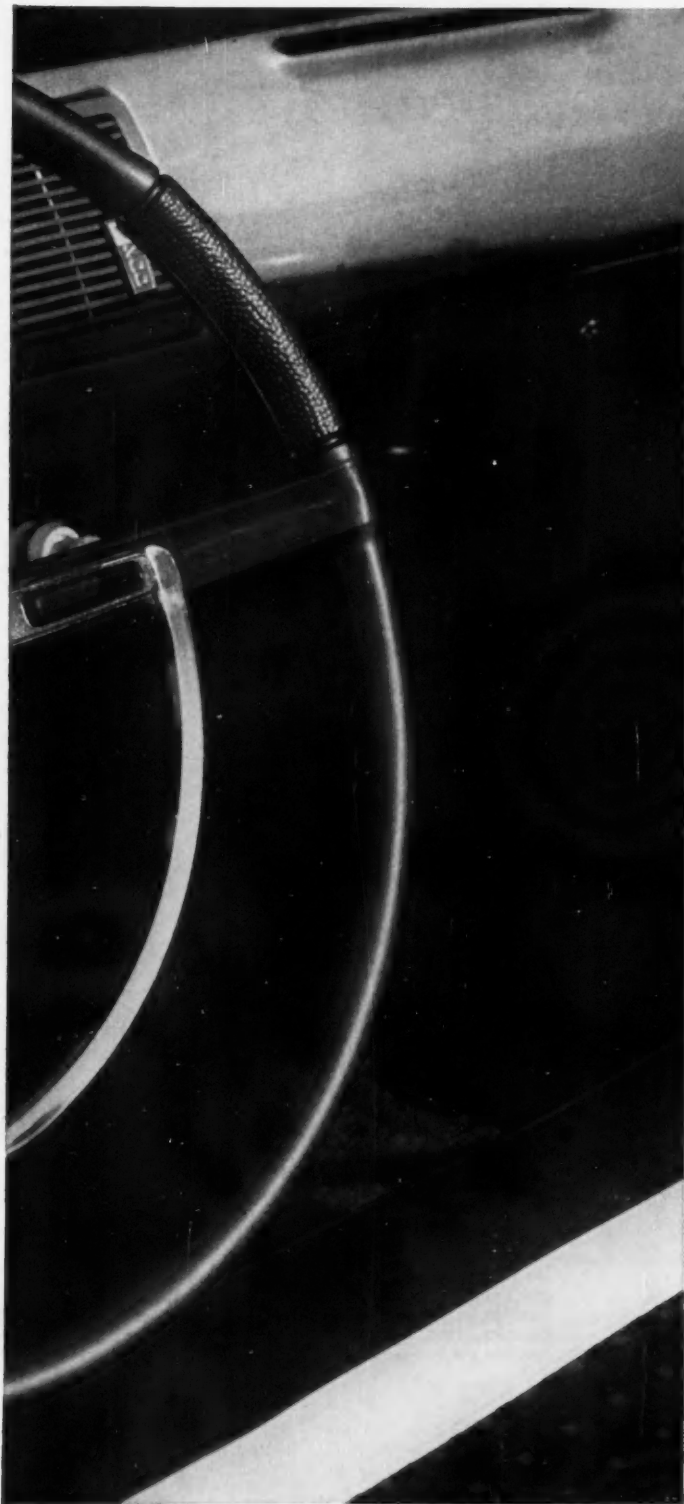
Study the chart above and see how the Eaton 3-Speed Gear Splits shown can improve your truck performance. Many other ratios available.

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* * *

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"AUTOPIA"—a new sound film in color—tells the complete story of our automotive facilities. If you are interested in seeing this film, write on your company letterhead to Sales Department, Automotive Division, The Budd Company, Detroit 15.

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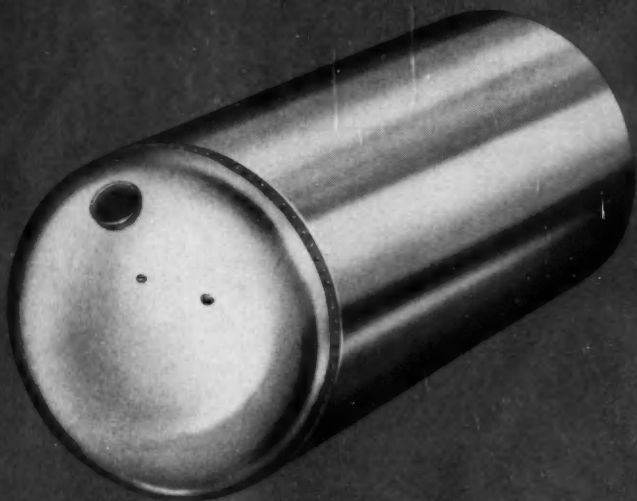
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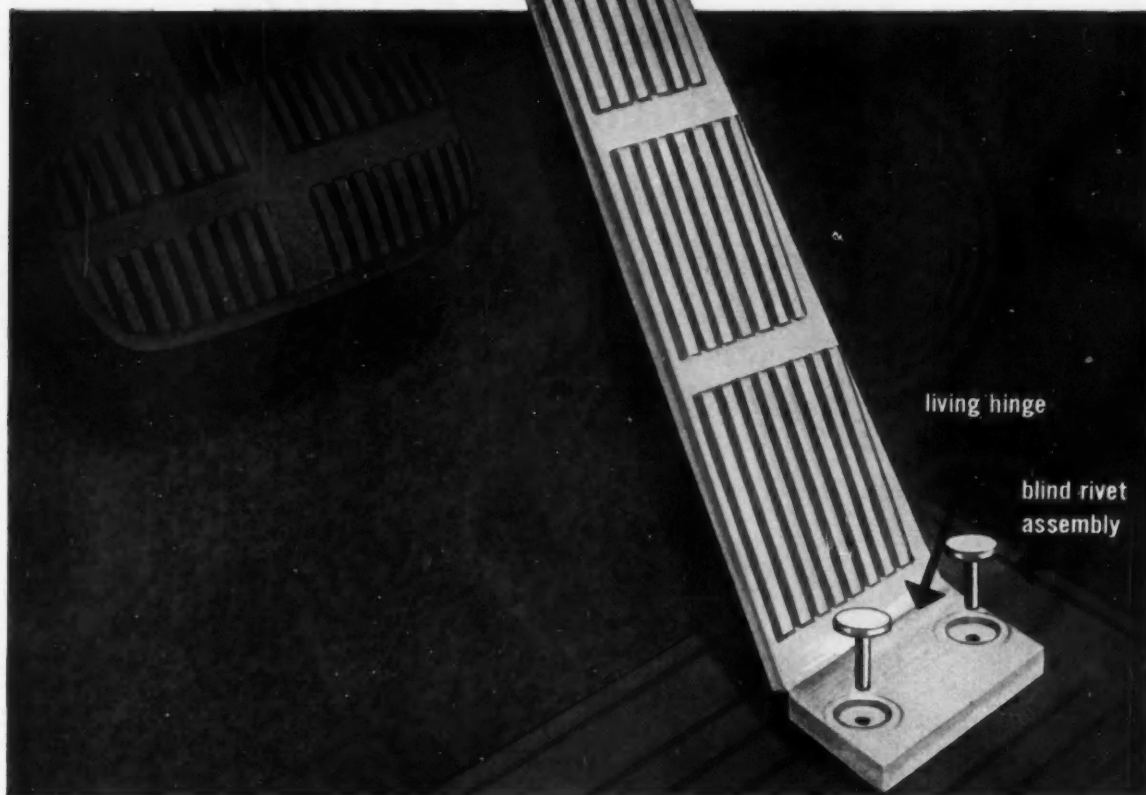
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Molded in one piece...



the hinge lives on and on... because it's Escon® polypropylene

Escon polypropylene defies fatigue—a fact demonstrated by the integral hinge molded into this accelerator pedal, which easily passes the severe requirements of the automotive industry. The high strength and resilience of Escon polypropylene permit blind rivet assembly for fast, economical mounting to the floor panel.

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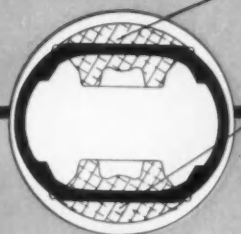
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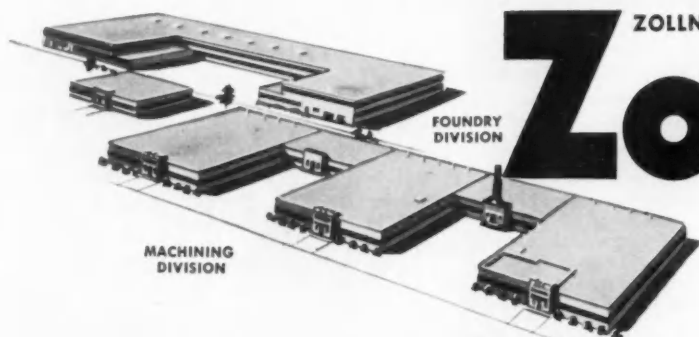
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**silence,
please...**



No rattles, no squeaks, no wind noises in this car window.

That's the kind of silence you install with Schlegel woven pile liner.

This thick pile runs uniform through the length of the glass channel. It smothers noises before they start.

It's a resilient pile. It hugs the surface of the glass tightly—but not so tightly that it restricts window movement.

It's a protective pile. It effectively seals out dust, wind and moisture.

And it's a permanent pile. Each individual strand of pile yarn is interlocked with the woven fabric backing. Thousands of opening and closing actions will not affect this pile. Schlegel pile is a natural seal designed to retain its consistency under all conditions.

Silence? Of course. With proper resilience, density and pile height, a Schlegel woven pile will satisfy the most critical design engineer—but, most of all, dealer and customer satisfaction is assured.

Like to install silence in your automobile windows? Specify Schlegel woven pile in your glass run channels and weatherstripping. They've been used in the quieter cars for decades.



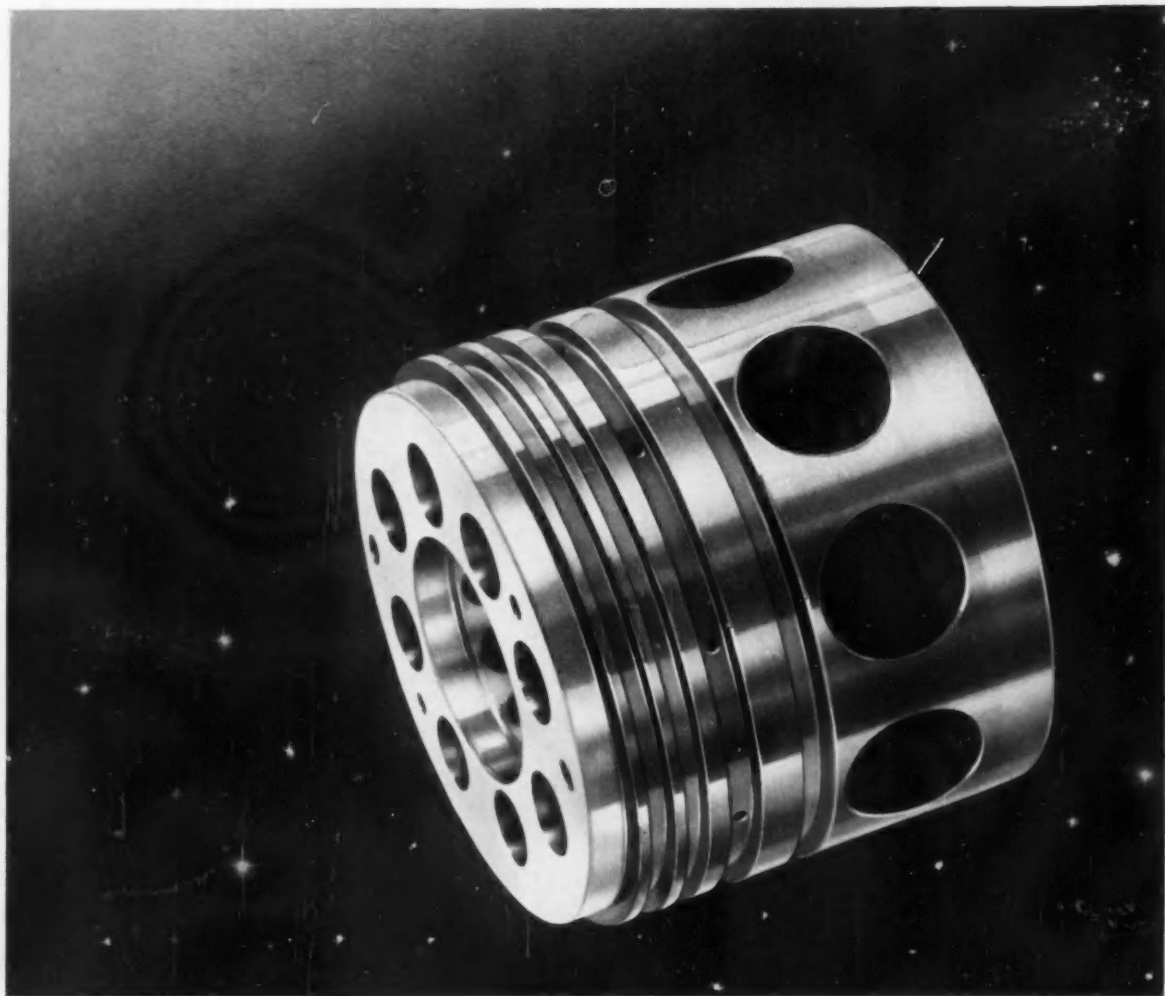
Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile liner.

Schlegel

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